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MODERN GEOGRAPHY

BOOK I

FOUNDATIONS OF GEOGRAPHY

BY

D. M. PREECE

SENIOR GEOGRAPHY MISTRESS, CREWE SECONDARY SCHOOL
EXAMINER IN GEOGRAPHY FOR THE OXFORD SCHOOL
CERTIFICATE EXAMINATION

AND

H. R. B. WOOD, M.A.

DIRECTOR OF EDUCATION FOR WALLASEY, FORMERLY LECTURER IN GEOGRAPHY, ST. MARY'S TRAINING COLLEGE, STRAWBERRY HILL

LONDON
UNIVERSITY TUTORIAL PRESS LD.
CLIFTON HOUSE, EUSTON ROAD, N.W. 1

MODERN GEOGRAPHY

A course in general and regional geography for schools.

By D. M. PREECE and H. R. B. WOOD, M.A.

BOOK I. FOUNDATIONS OF GEOGRAPHY.

BOOK II. THE BRITISH ISLES.

BOOK III. EUROPE.

Three other volumes in preparation.

Published 1938
Second Impression 1939

PRINTED IN GREAT BRITAIN BY UNIVERSITY TUTORIAL PRESS LD.
FOXTON, NEAR CAMBRIDGE

PREFACE

Foundations of Geography is the first of a series of six books designed to meet the needs of pupils preparing for the School Certificate and other examinations of similar scope. It may be used with, or independently of, the remaining books of the series. In particular, it should be adequate for the " general " Geography paper which is now a feature of certain School Certificate examinations.

The modern enthusiasm for the so-called "human" Geography has in some measure led to the neglect of those aspects of the subject formerly known as " physical." Every teacher of Geography realises that unless he teaches the physical basis of his subject, unless he makes clear the general principles, his presentation of Regional Geography cannot be really effective. *Foundations of Geography* represents an attempt to gather together those essentials of world study upon which a satisfactory presentation of the subject must rest. The book may be regarded as a companion volume to the regional books and as appropriate for use throughout the greater part of the school course.

Special attention has been paid to the provision of adequate illustrations and diagrams, and in particular to the introductory study of Ordnance Maps.

The authors wish to express their thanks to Mr. W. Hannah of Crewe County Secondary School for the valuable help he has at all times so willingly given, and also to the London Midland and Scottish Railway, the Canadian Pacific Railway, Imperial Airways, German Railways Information Bureau,

Commissioner of European Immigration for Canada, The High Commissioner for South Africa, Canal Maritime de Suez, Swiss Federal Railways, Royal Hungarian Legation, K.L.M., Royal Dutch Air Lines, International Tea Market Expansion Board, Ltd., for kindly providing the prints from which some of the illustrations have been made.

Thanks are also due to the authors and publishers of the following works for permission to use diagrams from them: Morris Davis, *Physical Geography* (Ginn and Co., Ltd.); Professor S. J. Shand, *Earth Lore* (Thomas Murby and Co.); and the Northern Universities Joint Matriculation Board.

D. M. P.
H. R. B. W.

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FOUNDATIONS OF GEOGRAPHY

CHAPTER I

ORDNANCE SURVEY MAPS

The First Maps of Britain

The art of map-making is centuries old. The peoples of all ancient civilisations, Hindus, Greeks, Babylonians, Phoenicians, and Romans are known to have made maps both of small regions and of their conception of the known world. The earliest known map of England is that drawn by Ptolemy, the famous Roman geographer, probably in the second century of the Christian era. For nearly a thousand years after the death of Ptolemy no noteworthy maps of Britain were made.

About 1250 A.D. a monk, Matthew Paris, drew a map of Britain which, though inaccurate, is of interest because it marked the real beginning of the mapping of Great Britain. About 1300 another map, now in the Bodleian Library, was drawn in colour. Roads, towns, and rivers were shown on a scale (approximately 18 miles to 1 inch) corresponding closely to that of the modern 1 : 1,000,000 International map. For nearly 300 years this remained the best map of England. During the sixteenth century more maps were made, notably by George Lily and Mercator, and in 1570, Christopher Saxton, the real father of English map-making, began his survey of the counties of England and Wales.

Saxton's county maps, on a scale of about 4 miles to 1 inch, are well known. They show hills, rivers, and towns, but no roads. The hills are drawn in profile, so that a map of a hilly county has the appearance of a field of haycocks. A contemporary of Saxton, John Norden, produced about half a dozen county maps on which the roads were also marked.

The real work of surveying roads began in the seventeenth century, when John Ogilby compiled a Road Book (1675). Of note, too, is the work of John Rocque who made very detailed maps of London, Middlesex, and Surrey on a scale of 2 inches to 1 mile. These are so detailed that every house, road, brook, and woodland is shown, so that in many ways

they foreshadow the later work of the Ordnance Survey. At the end of the eighteenth century the value of accurate and detailed maps was beginning to be fully realised, and the publication of numbers of county maps followed. This was largely due to the generosity of the Royal Society, which offered large prizes for the best maps on the scale of 1 inch to 1 mile.

The Growth of the Ordnance Survey Department

The dictionary definition of the word "Ordnance" is "cannon, artillery, etc.", and one may be inclined to ask why a term of military meaning should be applied to the apparently non-military occupation of surveying. The answer lies in the fact that maps are of inestimable value in military campaigns. In Britain this was fully realised during the 1745 Rebellion, when the idea originated of making reliable maps of the Scottish Highlands. These maps were made for the Army under the direction of Major-General Roy, who after the completion of his work in Scotland, was, in 1765, appointed "Surveyor General of Coasts, and Engineer for making Military surveys in Great Britain." Roy died in 1790, having done valuable work in both actual surveying and in investigating remains of historical interest, especially those of Roman origin. Before his death he repeatedly advocated the detailed survey of the whole of Britain, and in 1791 the Government officially established the Trigonometrical Survey of Britain. Thus began the "Great Triangulation" which was not completed until 1853.

Triangulation is a system of measurement based on the fact that if one side and two angles of a triangle are accurately known, then the exact lengths of the other two sides can be calculated. Let A, B, and C (Fig. 1) be three prominent landmarks. Then if the side AB (the base line) is accurately measured, and also the angles BAC and ABC, it is possible to calculate the exact lengths of BC and AC. If D is another landmark, then after measuring the angles DCB and CBD and using the *calculated* length of BC the exact lengths of CD and BD can be obtained. So the surveyor proceeds from triangle to triangle, and it is never again necessary to measure any linear distances.

For the first triangulation of Great Britain two base lines were measured, one on Salisbury Plain and one near Lough

Foyle in Ireland. Later a side of a triangle was *measured* in Scotland as a test, and so accurate was the process of triangulation that the error was only one inch per mile. The instrument generally used to measure the angles is known as a theodolite. The sides of the triangles of the primary triangulation were of the order of about 30 miles long. Sometimes the sides of these main triangles were divided and smaller triangles observed, and these again were further subdivided if desired. All the major features of the land were thus fixed in accurate relation to one another. Further details were then filled in by various other methods of surveying, viz. by the use of measuring chains, the plane table, the prismatic compass, etc. The first official Ordnance

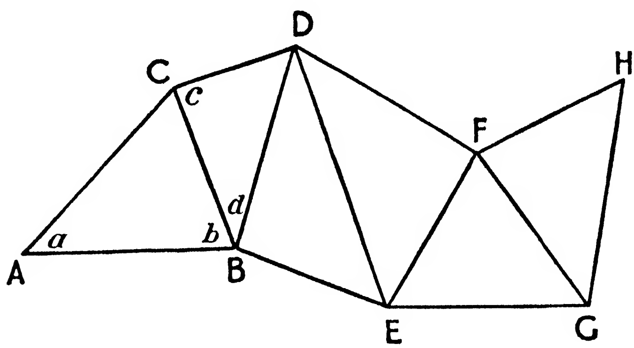


Fig. 1. PRINCIPLE OF TRIANGULATION.

Survey map to be published was that of Kent (1801). The scale was 1 inch to 1 mile, and on it were marked towns, villages, streams, roads, wood, and parks. Relief was shown by hachuring (see page 9).

The year 1824 marked the next step in the progress of the Ordnance Survey. It was then that a survey of Ireland on the scale of 6 inches to 1 mile was authorised. In 1840 a similar survey of Great Britain was commenced. Finally in 1863 it was decided to survey the whole of Great Britain, except for mountainous and barren areas, on the scale of 25 inches to 1 mile. When this was completed the work of revising the earlier maps began, *i.e.* the insertion of new roads, railways, houses, etc. Each one-inch map is supposed to be revised every fifteen years, but the World War retarded

this work. Apart from the revision of existing maps the Ordnance Survey is engaged in the general improvement of all maps. The first of the O.S. maps were printed entirely in black; to-day most of them are printed in well chosen colours, and are, therefore, much more easily read.

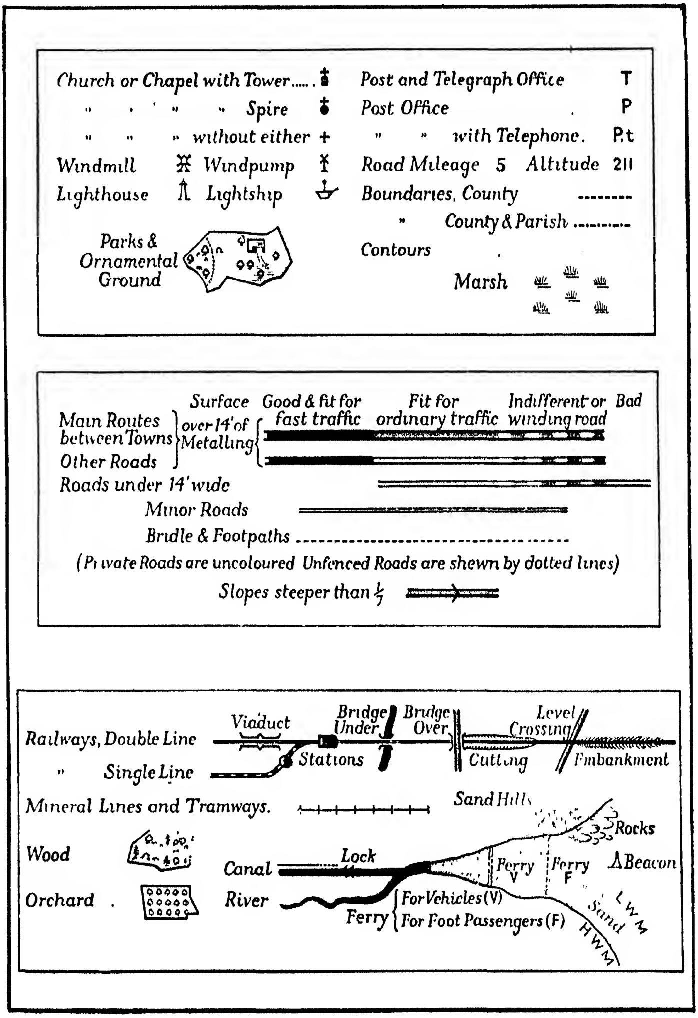
The Ordnance Survey Department has also published Geological Survey maps on a scale of 1 inch to 1 mile for the whole of Great Britain, and similar maps on a " six-inch " scale are in process of publication. Land Utilisation maps are also being published. These show woodland in dark green, meadow-land in light green, arable land in brown, heath, moorland, etc., in yellow, garden and orchards in purple, and land of no agricultural value in red. These colourings make it more difficult to decipher other details, but they are an interesting record of present day agriculture, and useful for the study of a given locality.

Types of Maps

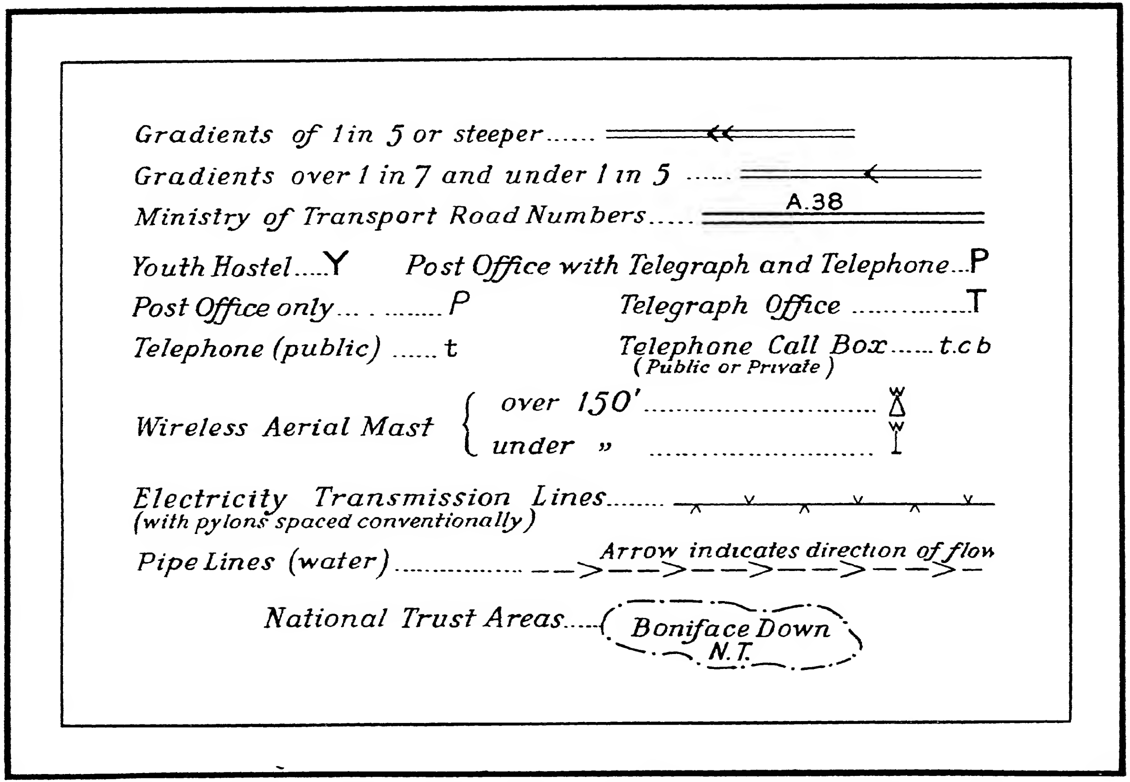
(*a*) ONE-INCH MAPS.—The best known of the " one-inch " maps to-day is probably the " Popular Edition," the publication of which was finished in 1931. On this map contour lines are drawn in red at intervals of 50 ft. Rivers and lakes are marked in blue, woods and parks in green, roads in brown, and railways in black. The principal signs used with their appropriate colouring are shown on the illustration facing page 4. In 1931 a new edition, the Fifth Edition was commenced but is not yet available for the whole of Britain. It differs from the Popular (Fourth) Edition in that improved symbols have been used for railways and roads, and that a number of new signs have been introduced to indicate such new features as are shown on the illustration facing page 5. For the districts covering the South-West of England and the neighbourhood of London a Fifth (Relief) edition has also been issued, in which the relief is shown by brown hachures and faint "layer" tints in addition to red contouring. The publication of this Edition has now been discontinued, and when the present stocks are exhausted will no longer be on sale.

Probably the most beautiful maps of all are those of the "Tourist Edition," limited to specially selected areas, *e.g.* N. Wales, the Peak District, Dartmoor, Isle of Wight, etc. Relief is shown by layers of colour in addition to contours.

ORDNANCE SURVEY.



SYMBOLS USED IN THE ONE-INCH MAPS POPULAR EDITION.
(Slight variations of these occur in other O.S. Editions.)



Some of the Additional Signs used in the latest (Fifth) Edition of the One-Inch Ordnance Survey Maps.

(*b*) Six-Inch Maps.—These maps are printed in black, with contours in red, at vertical intervals of 50 ft. A greater number of conventional signs are used to differentiate, for instance, between different types of vegetation. Boundaries of towns, urban districts, rural districts, etc., are shown by various types of broken lines. Every field is shown, and all bench marks (*i.e.* points whose height above sea-level has been accurately determined) are inserted.

(*c*) Twenty-Five-Inch Maps.—This type of map is really a plan. The fields are not only shown, but they are numbered and their areas denoted to a thousandth part of an acre. In a town it is possible to pick out every street, house, garden, school, and public building. In this map the roads are of their true width (this is not possible in the maps of smaller scales, *e.g.* the one-inch maps). Such maps are extremely useful to town councils and other local government bodies.

Map Reading

At the end of this book is a portion of the "One-inch" Popular Edition of part of the South Downs. Continual reference is made to this map in the following pages.

To read a map intelligently it is necessary not only to be familiar with the conventional signs used, but to understand fully the scales and to be able to interpret the relief as shown by contouring or other means.

Conventional Signs

These are shown opposite pages 4 and 5. In addition antiquities are shown on the map in special type. Roman remains are marked with square Roman lettering, *e.g.* STANE STREET (square D4) and CAMP (B6). Other features of historical and antiquarian interest are indicated by Old English lettering, *e.g.* Tumuli (B3), Castle (C6). In order to become familiar with the signs used, work the following exercises using the specimen map.

Exercises

1. How many churches are there in squares A, B, C, 5, 6, 7? Classify them according to whether they have spires, towers, or neither spire nor tower.

2. Give the meanings of the letter P at Coldwaltham (B6), the letter T near West Dean (D1).

3. If you lived at Bignor (C5) where would you go to (*a*) send a telegram; (*b*) post a letter?

4. If you lived in South Stoke (D6) where would you go to send a telegram?

5. What do the following indicate: (*a*) The figure 426 on a main road (D6); (*b*) the figure 3 next to it? (Note that these two figures are printed in different type. One inch southwards along the road there is a figure 2 in the same type as the figure 3, and one inch northwards there is a figure 4 in similar type.)

6. What do the following indicate: (*a*) figure 174 on the main road (D1); (*b*) figure 11 on the main road south of Midhurst (A2)?

7. How would you go from North Stoke (D6) to Houghton (D6)?

8. What route would you follow if you were (*a*) motoring; (*b*) walking from Amberley (C6) to Bury (C6)? Why do the routes you choose differ?

9. Find examples of coniferous woods, deciduous woods, parks, inns, lakes, canals.

10. Find as many examples as possible of (*a*) Roman remains; (*b*) other historical remains.

11. How does the railway linking Midhurst (A2) with Chichester (F1) differ in type from that linking Pulborough (B7) with Arundel (E6)?

12. Which railway station is most easily accessible from South Stoke (D6), (*a*) by car; (*b*) on foot?

13. What is the direction (*a*) from Arundel (E6) to Houghton (D6); (*b*) from Rackham (C7) to Upwaltham (C4); (*c*) from Petworth (A5) to Singleton (C2); (*d*) from Summersdale (E1) to Fittleworth (B6)?

14. What is the difference between the Camp in D2 and the Camp in D1?

Scales

The scales of maps are linear scales. A scale denotes the relationship between the length of a *line* on a map and the length of that *line* on the ground.

Suppose a map or plan of a room 36 ft. by 12 ft. is required. It could be drawn 36 in. by 12 in. and give a true representation of the shape of the room. On such a plan 1 inch is used to represent 1 foot, so the scale is 1 inch to 1 foot. The sides of the room are each $\frac{1}{12}$ of their actual size. This scale can be denoted as 1 : 12 or $\frac{1}{12}$. This fraction is known as the *Representative Fraction* of the map (R.F.).

On " one-inch " maps 1 inch represents 1 mile. Since a mile contains 63,360 inches, and 1 inch represents 1 mile, every line on the map is $\frac{1}{63360}$ of its actual size on the ground. In atlases the Representative Fraction of each map is usually given in addition to an ordinary " line " scale. Suppose a Representative Fraction of an atlas map is 1 : 2,000,000, then 1 inch represents 2,000,000 inches. But 2,000,000 inches are the equivalent of nearly 32 miles, so that the scale 1 : 2,000,000 can be approximately expressed as " 1 inch to 32 miles." Why should two kinds of scales be used ? The reason is that fractional scales can be understood in any country. For example, a French boy would not readily grasp the meaning of " 1 inch to 1 mile," in relation to French linear measurements. He would therefore look at the Representative Fraction, $\frac{1}{63360}$, and interpret it as 1 centimetre to 63,360 centimetres, *i.e.* 1 centimetre to ·63 kilometres. Thus he would quickly grasp the scale of the English map.

Examine the linear scale on the given map. It is divided into 6 equal divisions of 1 inch each representing 1 mile. Note carefully that the figure 0 is not placed at the extreme left-hand end, but at the right-hand end of the first division. To the left of the figure 0 the first division is divided into 8 divisions of 1 furlong each, while to the right are 5 undivided spaces each representing 1 mile. This convention of placing the 0 at the end of the first division is to facilitate the measuring of distances on the map. For example, suppose the distance between West Dean railway station (E1) and Singleton station (C1) has been measured with dividers. Then if the right-hand point of the dividers

were placed on the figure denoting 2 miles on the scale, the left-hand point would be on figure 7 in the first division. The distance between the two stations is therefore 2 miles 7 furlongs.

If scales give the relationship between *lines* on the map and *lines* on the ground, what will be the relationship between *areas* on the map and *areas* on the ground?

Suppose the top of your school desk is 30 in. by 20 in. Draw a plan of the desk top on a scale of 1 : 10. Your plan will be 3 in. by 2 in. Cut out this piece of paper and find how many such pieces would be required to cover the whole desk top. The required number is 100. The area of the plan is $\frac{1}{100}$ or $\left(\frac{1}{10^2}\right)$ of the area of the desk top. Therefore if the linear scale is $\frac{1}{10}$ the area scale is $\frac{1}{(10)^2}$. On a "one-inch" map 1 sq. in. represents 1 sq. ml. But there are $(63{,}360)^2$ sq. in. in 1 sq. ml. Therefore the relation between the *area* of the map and the *area* of the ground is $\frac{1}{(63360)^2}$.

Exercises

1. What is the distance between Arundel station (F6) and Pulborough station (B7) as the crow flies?

2. What is the distance by road between Midhurst (A2) and Chichester (F1)? (Use a piece of fine string or cotton to make the measurement on the map.) Check your answer by the road mileage given on the map.

3. What area of land is represented by each of the squares on the map?

4. What is the total area of land surface represented by the whole map?

5. What fraction of its real size is Swanbourne Lake (E6)?

6. Which is the shorter route (railway or road) between Arundel (E6) and Chichester (F1)?

7. What is the R.F. of a map whose linear scale is (*a*) 1 in. to 2 ml.; (*b*) 25 in. to 1 ml.; (*c*) 6 in. to 1 ml.; (*d*) 1 in. to 10 ml.; (*e*) 1 cm. to 1 km.?

8. Express the following scales by an alternative method: (*a*) $\frac{1}{2500}$; (*b*) 1 : 1,000,000; (*c*) 1 : 31,680.

The Representation of Relief

The principal methods of showing relief on a map are by (*a*) hachuring; (*b*) hill-shading; (*c*) contours; (*d*) form lines; (*e*) contouring, with layering of colours. Sometimes two of these methods are combined, *e.g.* contours and hachures as in the new Relief edition of the " one-inch " maps.

(*a*) HACHURES [Fig. 2 (*a*)].—Hachures are short lines representing the way in which water would flow from high to low ground. On steep slopes they are closer together than on the gentle slopes, but on flat ground there are none at all. The disadvantage of the use of hachuring alone is that it gives no indication of the actual height, and that both high plateaux and low plains are unshaded. The close hachuring

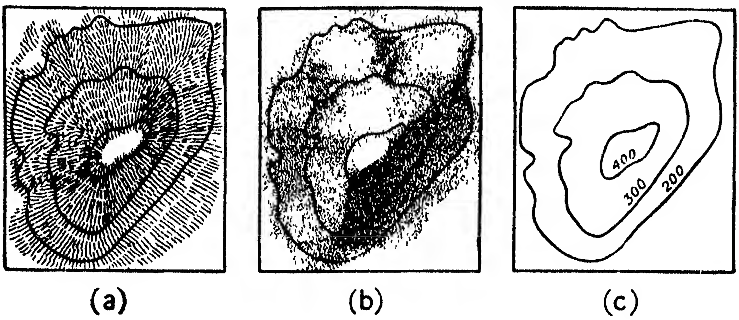


Fig. 2. THE REPRESENTATION OF RELIEF.—(*a*) Hachuring (with contours,) (*b*) Hill-Shading (with contours), (*c*) Contours.

of mountainous areas tends to obscure the other details of a map. Hachuring, however, gives the map a modelled appearance, and the relief features stand out clearly.

(*b*) HILL-SHADING [Fig. 2 (*b*)].—Hill-shading shows the relief by " light and shade." Two methods are generally adopted. (i) A light is imagined to be vertically over the area mapped. The steep slopes are then shown by dark shading, and the level land, whether of high or low altitude, is unshaded. (ii) A light is imagined to be shining from the north-west so that south and east-facing slopes are more darkly shaded than those facing north and west. Both methods give a good general idea of the relief of the country, but the disadvantages are similar to those of hachuring, viz. that hill-shading does

not give any idea of actual height, and that it is sometimes difficult to know whether a piece of land is sloping uphill or downhill.

(*c*) CONTOURS [Fig. 2 (*c*)].—*A contour line is a line joining all places which are the same height above sea-level.* The coastline is a simple example of a contour line since it joins all places 0 ft. above sea-level. Since a water surface is level it follows that the edge of a pond or lake is also a contour line. Contouring is the most widely used method of showing relief. Most O.S. maps have contours drawn at vertical intervals of 50 ft., and in addition numbers of spot heights are marked. The position of the height of the contours and spot heights have been fixed by careful surveying with levels and other instruments.

(*d*) FORM LINES.—In many of the maps of British Colonies, where the surveys are as yet incomplete, form lines are used instead of contours. They are similar to contour lines but have not been accurately surveyed, and do not show definite heights. As a rule they are printed in broken lines, and so are easily distinguishable from contour lines.

(*e*) CONTOURING WITH LAYERING.—In this method layers or tints of colour are used to denote all the land between two given contours. For instance, dark green may be used for all the land between sea-level and 200 ft., light green for land between 200 ft. and 400 ft., etc. These maps are extremely clear and attractive, and the relief of the land is easily apparent. In regions of great elevation it is, however, difficult to produce a layered map in which different colours are used for each contour interval. This is the method used in the " Tourist " maps of special areas.

The Reading of Contours

Two terms are often used in relation to contours, viz. Vertical Interval (V.I.) and Horizontal Equivalent (H.E.). Examine Fig. 3. Suppose the line AB represents the surface of a piece of sloping ground. The dotted lines represent levels of 100 ft., 200 ft., and 300 ft. above sea-level. The Vertical Interval is the vertical distance between two contours (DE, FG). This is usually uniform, but on some maps the

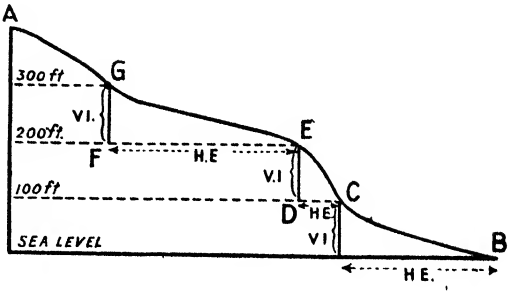


Fig. 3. Vertical Interval and Horizontal Equivalent.

V.I. is 100 ft. up to 1000 ft., and above 1000 ft. the V.I. is 250 ft. The Horizontal Equivalent is the horizontal distance between two contour lines, *i.e.* CD and EF. It varies according to the slope of the land, and is smaller where the slope is steep (EC) and larger where the slope is more gentle (GE). On a map the distance between the points C and E would be denoted by the shorter distance CD. All sloping surfaces are, as it were, projected on to a level plane before being mapped.

Exercises

1. The scale of a map is 1 : 10,560. On it a cliff railway is shown by a line 1·2 in. long. The lower station is 125 ft. and the upper 565 ft. above sea-level. If the slope is constant, what is the actual length of the railway?

2. A hill path of even slope is 520 ft. long. If the foot of the path is 300 ft. above sea-level and the path is shown by a line 1 in. long on a scale of 1 : 5760, what will be the height of the top of the path above sea-level?

Sections

One of the easiest ways of acquiring facility in reading contours is by drawing *sections.* The method is as follows:—

Suppose it is required to draw a section from A to B (Fig. 4). Draw a line A′B′ equal in length to AB. At each end erect a vertical line (A′C and B′D). Examination of the map shows that the greatest height crossed by AB is between 600 and 700 ft. Mark off along A′C and B′D seven divisions of $\frac{1}{10}$ in. each; through these points draw seven fine lines parallel to A′B′, and number them in hundreds of feet (or according to the contour interval of the given map). Place the straight edge of a piece of paper along the line AB and on it

map carefully all the points at which AB is crossed by contour lines. Place the edge of the paper along the line A′B′ and mark the contour points on this line. At each of these points E, F, G, etc., erect a vertical. The vertical line at E corresponds to the point where the 100 ft. contour crosses AB on the map. Therefore put a dot on this line where it is crossed by the horizontal line for 100 ft. Continue this process, being careful to note that at G and H, J and K, and L and M,

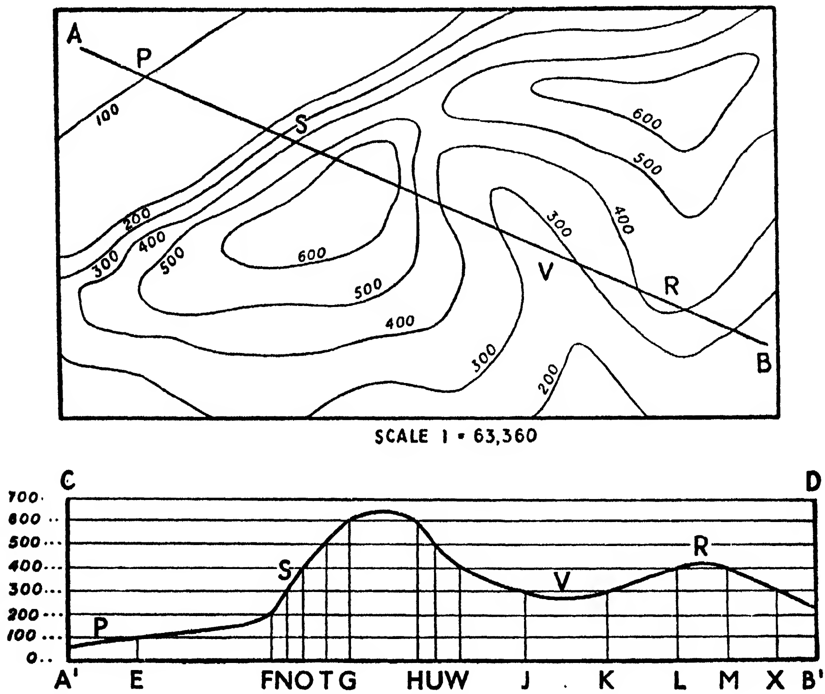


Fig. 4.

neighbouring contours, are of equal height. Join up the dots Between G and H it is obvious that the section line must be carried above 600 ft., but it must not touch 700 ft. In the same way the line between J and K must dip but must not touch 200 ft. The section thus drawn reveals the chief relief features of the map, viz. a plain (P), a steep slope (S), a valley (V), and a ridge (R). It should be noted that while the horizontal scale is 1 in. to 1 ml., 1 : 63,360, the vertical scale is $\frac{1}{10}$ ft. to 100 ft., *i.e.* 1 in. to 1000 ft., or about

5¼ in. to the mile. In other words the vertical scale is exaggerated about five-fold in relation to the horizontal scale.

Similar methods are used for drawing profiles of roads and rivers. But as these are not straight lines the lengths of the road and the horizontal intervals between the contours must be measured separately with a piece of cotton or string. The effect of this is to straighten out the road or river, and to give their slopes in relation to their full length.

Exercises

1. Draw a section from Rackham (C7) to Burpham (E7).

2. Draw a section from Camp Hill (D7) through South Stoke (D6) to the point 348 in Arundel Park (E6).

3. Draw a section of the Lavant valley (take an east to west line through the middle of square D1).

4. Construct a profile of the main road between Petworth (A5) and Petworth station (B4).

5. Construct a profile of the main road between Singleton (C2) and Cocking (B2).

6. Construct a profile of the main road between Upwaltham (C4) and Duncton (B4). Why is one section of this road so winding?

7. Draw a profile of the hill-top road from Linch Down (B1) to Bishop's Ring (C4).

8. Draw a section along the N.-S. grid line between squares 4 and 5 from Glatting Farm to the word "Slindon."

Intervisibility of Places

It is often an advantage when reading a map to know whether one place can be seen from another and vice versa. This can usually be determined by an examination of the contours.

(1) Where the contouring shows a convex slope (see HK, Fig. 11) the top of the hill is not visible from the foot of a hill.

(2) Where the contouring shows a concave slope (see LM, Fig. 11) the summit and foot of a hill are intervisible.

It must not be forgotten, however, that minor eminences, woods and buildings may obscure the view of a point which by consideration of the contours alone would appear to be easily visible.

(3) Two points of the same height are intervisible if there is no higher land between them.

(4) Two points of unequal height *may or may not* be intervisible if there is no land intervening which rises above the level of the higher of the two points. In such examples

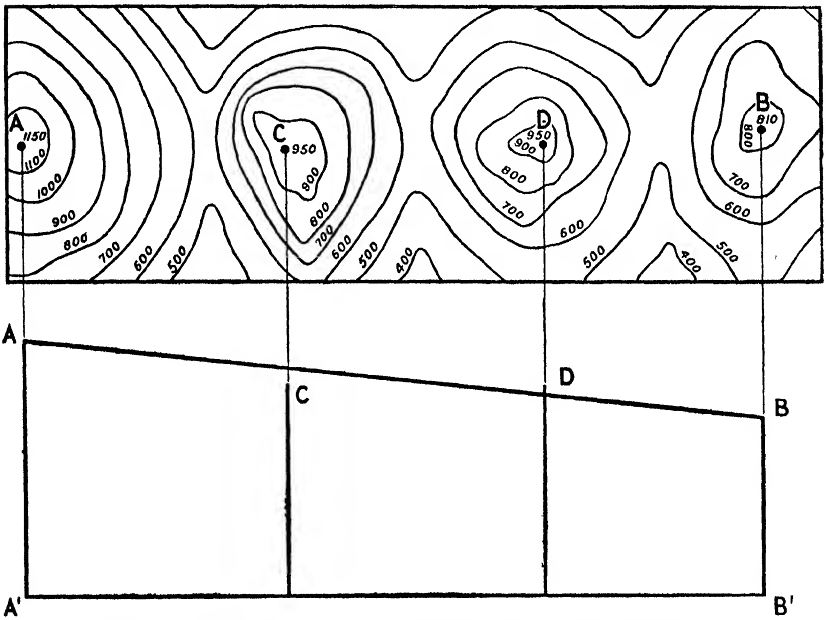
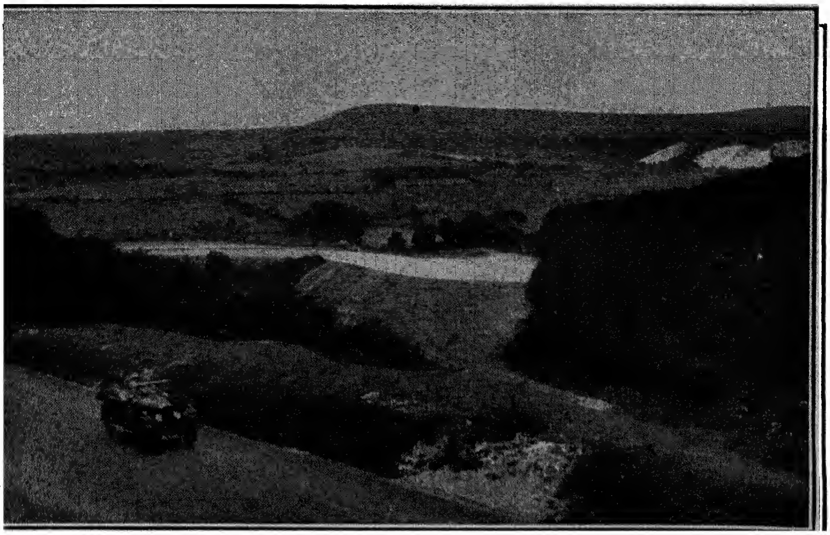


Fig. 5. One Method of Determining Intervisibility.

the easiest way to determine whether the points are intervisible or not is to draw a " Skeleton Section."

Example. Are the points A and B on Fig. 5 intervisible ?

This figure shows four hills: A, B, C, D. Neither C nor D are higher than A, but both are higher than B. Join AB, and pick out the highest points on this line between A and B. These are C and D. Draw a line A′B′ equal in length to AB. At A′ erect a perpendicular to represent 1150 ft. on a scale of $\frac{1}{10}$ in. to 100 ft., *i.e.* 1·15 in. At a distance AC from A′



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VIEW FROM BURY HILL, SUSSEX.

This picture was taken looking eastwards. Try to identify the features shown on the map with those shown on the picture.

erect a perpendicular to represent the height of hill C, viz. 950 ft. (the line will be ·95 in.). At a distance AD from A′ draw a perpendicular to represent the height of hill D (*i.e.* ·95 in.). At B′ mark off a line (·81 in.) to represent the height of hill B. Join AB on the skeleton section. It will be seen that although hill C does not rise above the line, the hill D does and so blocks the view. A and B are therefore not intervisible.

EXERCISES

1. Is Bignor Hill (C5) visible from the Roman Villa (C5)?

2. Is the point 515 (D2) visible from Levin Down (C2)? If so, why?

3. Is the highest point of Barlavington Down (C4) visible from the inn at Duncton (B4)?

Views

Example. Describe the view looking south from the inn on the main road at Tillington (A4).

"In the foreground is a farm beyond which are fields, with very little woodland, sloping southwards to the river valley. Beyond is a belt of undulating land, heavily wooded, which rises to a forested scarp with an even sky line."

In writing a description of a view, care should be taken to bring out the *salient* features and to avoid long descriptions of too many details. It should be remembered that trees, buildings, and even gentle slopes obscure the view of objects clearly marked on the map. For instance, in the above example, neither river nor railway is visible because each lies in a hollow.

EXERCISES

1. Describe the view looking S.E. from the Inn at Watersfield (C6).
2. Describe the view from the point 145 in Cowdray Park (A2) looking towards Cocking (B2).
3. Describe the view looking south from the tower of Arundel church (E6).

Gradients

By a study of the contours and spot heights on a map it is possible to ascertain the gradient or slope of hillsides, roads, etc. To find the average gradient between two points on a map it is necessary to know (*a*) the height of both the places, and (*b*) the distance between them.

Example. On the given map what is the average gradient of the road between the cross roads at Pulborough (B7) and the inn on Codmore Hill (A7)?

Height at inn above sea-level (by spot height) is .. 158 ft.
Height at cross roads above sea-level (by contour) is 50 ft.
Difference in height between the two places is .. 108 ft.
Distance between the two places is 1·15 ml. by measurement.
There is therefore a rise of 108 ft. in .. 1·15 ml.
" " " " " " 108 ft. in .. 1·15 × 5280 ft.
" " " " " " 1 ft. in .. $\frac{1{\cdot}15 \times 5280 \text{ ft.}}{108 \text{ ft.}}$

∴ There is rise of 1 ft. in 56 ft. (approximately).
The gradient is 1 in 56.

Exercises

1. What is the average gradient of the hillside between the figure 135 on the main road (C7) and the figure 636 on Rackham Hill (D7)?

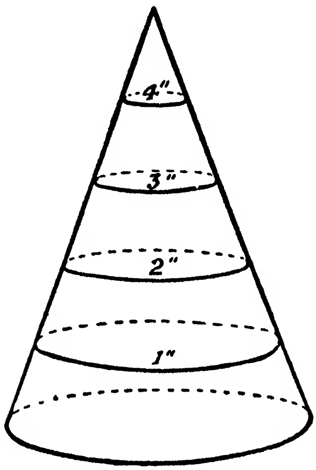


Fig. 6.

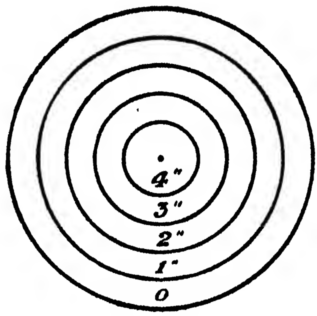


Fig. 7.

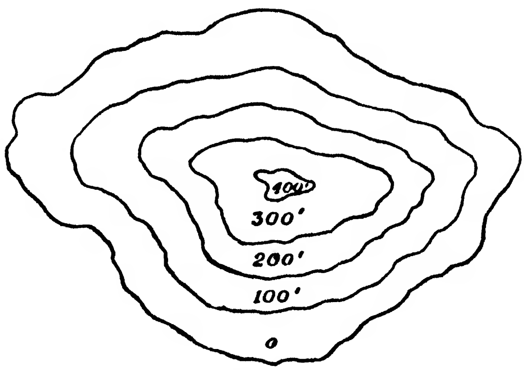


Fig. 8.

2. What is the average gradient of the main road between the road junction at Westhampnett (F2) and Warehead Farm (E3)?

3. What is the average gradient of the road between the road junction in Houghton (D6) and the cross roads near Whiteways Lodge (D6)?

4. Find the average gradient of the railway between the station at Mid Lavant (E1) and the south end of the railway tunnel (B1).

Some Typical Contour Forms

Since contours are so generally used to show relief on O.S. maps it is necessary that the contouring of the chief types of relief features should be easily and quickly recognised.

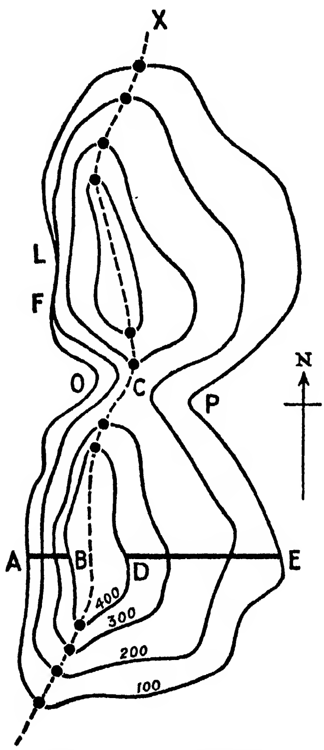


Fig. 9. WATERSHED.

If lines are drawn round a cone (Fig. 6) so that the first is 1 in. above the base all the way round; the second 2 in., and so on, then viewed from above the lines would appear as concentric circles (Fig. 7). This would be a contour map of a cone. Fig. 8 represents a contour map of an island rising from the coast to hill just over 400 ft. high.

Fig. 9 represents a hilly ridge rising to over 400 ft. On the west the hill rises 300 ft. in the distance AB, but on the east of the ridge the land rises 300 ft. in the longer distance DE. It is clear then that the western side of the ridge is steeper than the eastern side. Contours drawn closely together denote steep slopes, and those farther apart denote gentle slopes. Such a ridge is known as an escarpment or scarped ridge. The western slope is known as the *scarp slope*, and the eastern slope as the *dip slope*. Contour lines cannot cross one another, but at LF the 200 ft. contour meets the 100 ft. contour and the two are coincident for a short distance. This indicates that the slope is so steep that there is a vertical cliff at least 100 ft. high. Coastal cliffs are shown by contours in this way. Between the points O and P it is possible to cross the ridge without climbing to a height of 300 ft., while to cross the ridge further north or further south it would be

necessary to climb over 400 ft. Such a feature is known as a *col* or *saddle* (C). The dotted line XY represents the watershed. Some of the rain which falls on the ridge flows down the western slope and some down the eastern slope. The watershed is the line joining all the highest points so dividing the eastern drainage from the western drainage. The points (heavily dotted on Fig. 9) at which the watershed crosses each contour should be very carefully noted.

Find on the given map as many examples as possible of scarped slopes, cols, and dip slopes. For guidance there is a col where the main road crosses the highland to the south of Cocking (B2). A careful search will reveal other examples.

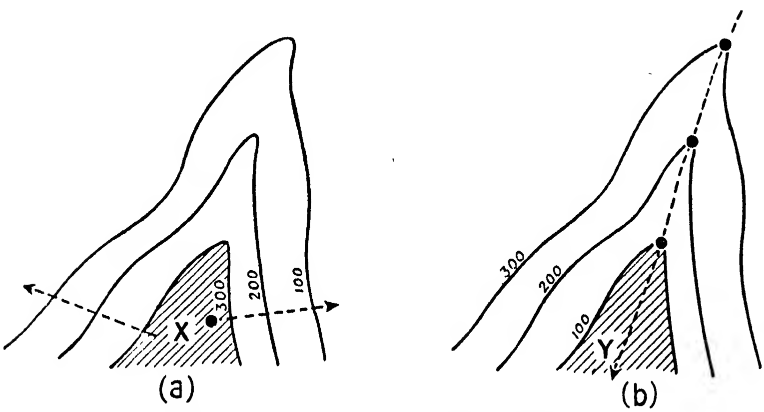
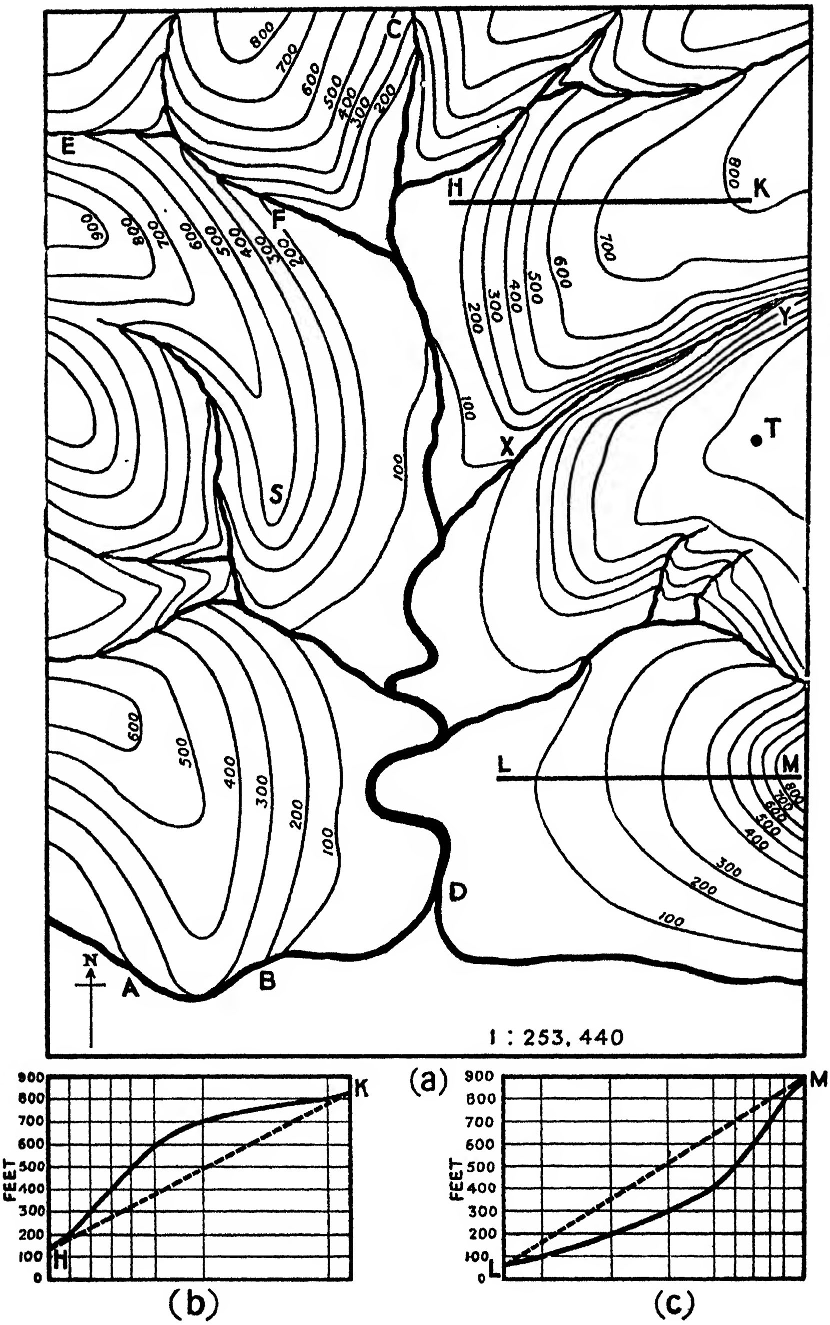


Fig. 10. (*a*) A SPUR. (*b*) A VALLEY.

Draw sections of these diagrams through X and Y.

Figs. 10(*a*) and 10(*b*) show two contour sketches of very similar V-shaped contours, but the numbering of these contours is different. Although at first sight they appear so similar, these two diagrams represent totally different relief features. In Fig. 10(*a*) the shaded region X is *higher* than the surrounding land, but in Fig. 10(*b*) the shaded region Y is *lower* than the surrounding land. Fig. 10(*a*) represents the end of a hilly ridge or *Spur*, but Fig. 10(*b*) represents part of the river valley. In Fig. 10(*a*) the drainage would flow outwards as shown by the dotted lines, but in Fig. 10(*b*) a river flows down the middle. The points (heavily dotted) at which the river crosses the contours should be carefully noted. *The V's of a river valley (re-entrant contours) point towards the source of a river.*


800
700
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C
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300
200
100
D
N
A
B
1 : 253, 440
(a)
900
800
700
600
500
400
300
200
100
0
FEET
H
K
(b)
900
800
700
600
500
400
300
200
100
0
FEET
L
M
(c)

Fig. 11.

Fig. 11(*a*) shows a river valley with numerous tributaries. In the upper courses of the tributaries, which are swift flowing, the contours cross the streams at short intervals. In contrast, in the slower lower course of the river, where it flows over a flat plain, the contours cross the river at more widely spaced intervals. The fall of the river between X and D is only 100 ft. in contrast to the fall of 400 ft. between the points E and F in the tributary valley. S is an example of a hill spur, and there are coastal cliffs and a headland between A and B. The tributary XY flows through a narrow steep-sided gorge. This is shown by the closeness of the contours on the valley sides. This map also illustrates another important point. Two lines HK and LM are marked. In walking from H to K you would rise quickly at first and then slowly as illustrated by Fig. 11(*b*). This is a *convex slope*, and is indicated by contours close together at the lower levels, and widely spaced at the higher levels. It is clear from Fig. 11(*a*) that the point K would not be visible from H as it is obscured by the brow of the hill. On the other hand, if you walked from L to M you would rise slowly at first and then quickly. This is a *concave slope* as illustrated on Fig. 11(*c*). It is indicated by the contours being widely spaced at the lower levels and close together at the higher levels. The point M would be visible from L.

Fig. 12 shows some of the principal features of a glaciated region. Before we study this map, pages 135 to 141 should be read carefully. From A to B is a long U-shaped valley with steep sides and a flat valley floor. This valley contains two long, narrow ribbon lakes which were formerly joined but which have been separated by a belt of alluvium deposited by the swift tributary from the S.E. At F the contours show that the main stream falls very quickly for a short distance. Such a " step " in the valley floor is characteristic of many glaciated valleys. Above the 1000 ft. contour the valley sides begin to slope more gently giving the " shoulder " outline of the valley sides (cf. the picture of the Lauterbrunnen valley on page 75). The tributary valley GH is a *hanging valley*. Between H and G the stream flows gently along its valley, but north-west of G it flows swiftly, probably with falls or rapids in its course, to the main valley floor. Similar rapids are denoted on other tributaries near K and L. M is a

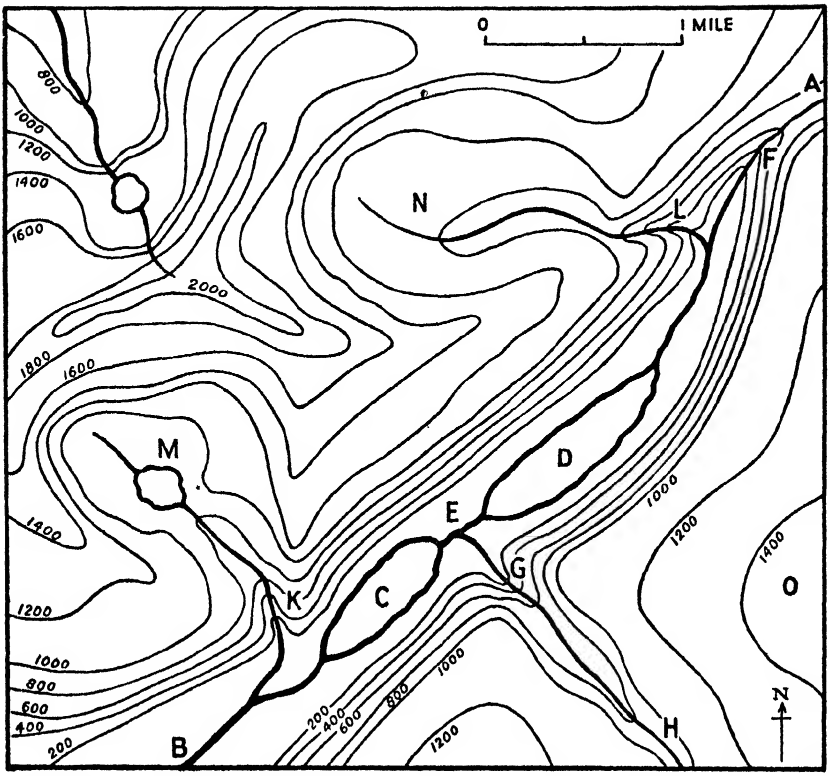


Fig. 12. A Glaciated Region.—(*a*) Draw a section from O to N to show the shape of the valley. (*b*) Compare this diagram with Fig. 76 (*b*).

mountain tarn set in a flat-bottomed, steep-sided, and roughly circular basin. This basin is an example of a *cirque*, *corrie*, or *cwm*. A similar relief feature is shown at N, but there is no tarn. Here the stream lowered its level sufficiently for the tarn to be drained away. In the region O the widely-spaced contours show the typical rounded tops of glaciated mountains.

Fig. 13 illustrates the features characteristic of a limestone plateau such as may be found in the southern Pennines. It shows a river flowing from A to B in a deep steep-sided valley. This valley differs from the glaciated valley because it is not flat-bottomed. The tributaries are also set in deep valleys, but some of the tributary valleys, *e.g.* CD and EF, contain no streams. These are dry valleys, the absence of streams being due to the porous nature of the limestone.

Above 900 ft. the contours are widely spaced and the slopes gentle. This is the plateau. Because the streams have cut deep valleys into the plateau it is known as a *dissected plateau.*

Fig. 14 represents the contouring of a lowland area. There are no steep slopes and the land surface rises and falls slowly. This is an example of a portion of an undulating plain.

While studying Fig. 15 it would be advisable to refer to Fig. 17. This contoured diagram represents a broad valley (a longitudinal valley) between a hilly district to the north and a scarped ridge to the south. The main river A to B is

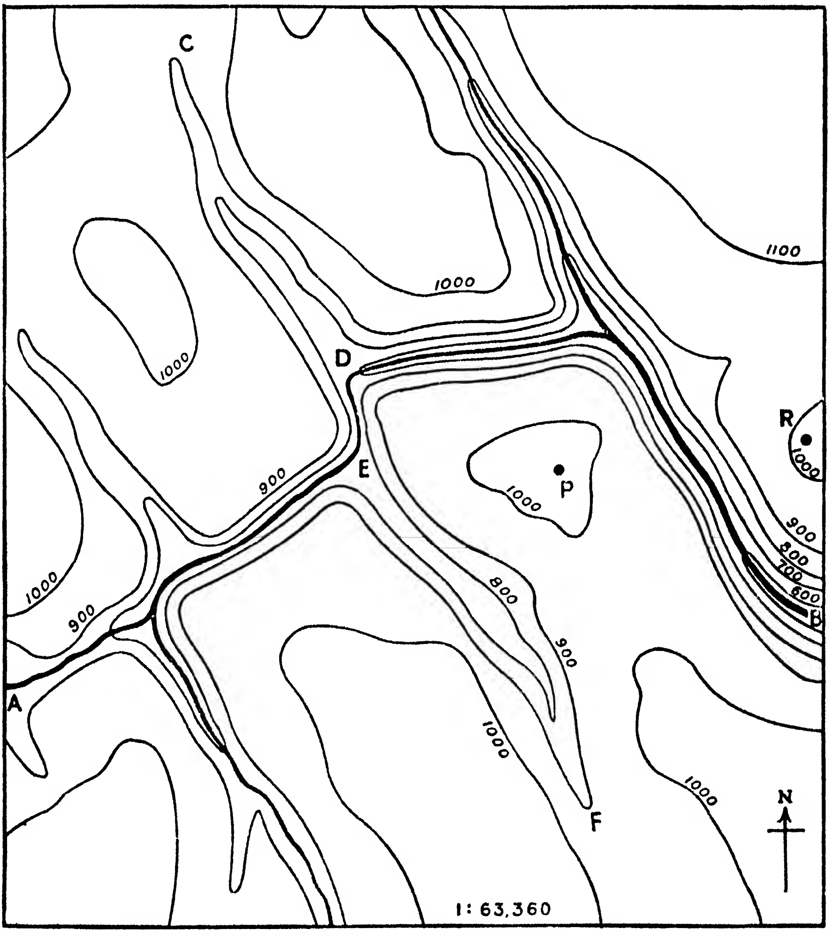


Fig. 13. A LIMESTONE PLATEAU.—Draw a section from P to R and contrast it with the section drawn for Fig. 12.

a consequent stream, while CE and DF are subsequent tributaries. The small tributary GH is an obsequent stream. The whole drainage system illustrates river capture. At W there is a wind gap, while the deep break in the ridge between K and L is a water gap. At M is an example of a col or saddle. This contoured diagram is especially important because features are in many ways similar to those of the O.S. map at the end of this volume.[1]

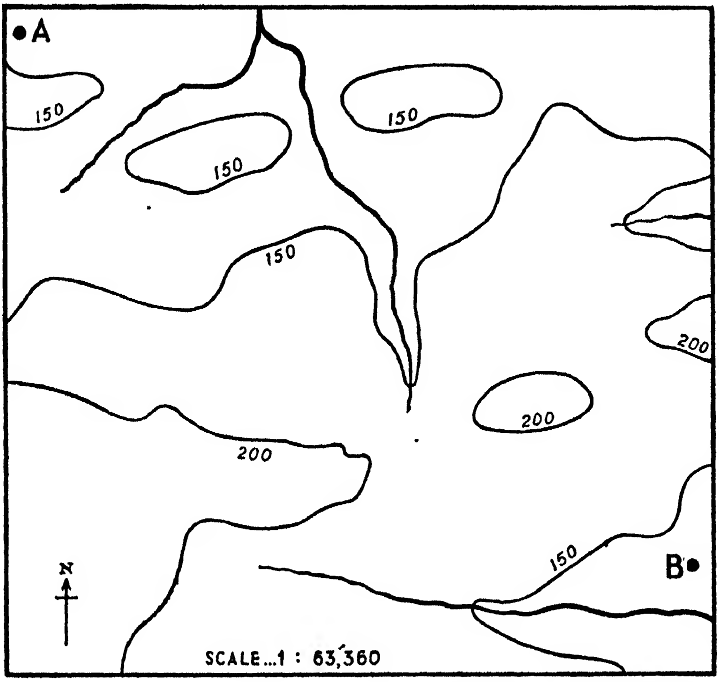


Fig. 14. AN UNDULATING PLAIN.—Draw a section from A to B. This will reveal the undulating character of the surface.

The Interpretation of the Relief Features of the Given Map

The map is divided into 42 squares, the sides of which measure 2 in. Draw a rectangle measuring 7 in. by 6 in. and divide it into 1 in. squares. Letter and number these squares in the margin just as they are on the map. Omitting

[1] Where there is difficulty in visualising the relief shown on the preceding diagrams 8-14 inclusive, it is suggested that tracings of these diagrams should be made and cardboard models constructed by superimposing on one another, in the correct position, layers of cardboard cut out in the shape of each successive contour.

all the minor curves, sketch into the framework, square by square, the main outline of the 250 ft. contour. Then lightly shade all the land which is over 250 ft. above sea-level. Print the word "steep" along the steepest side of the chief hilly region. Then insert with a blue pencil the river Arun (paying particular attention to the large meanders) and its tributary the river Rother, the river Lavant, and the small stream draining north from Cocking to Midhurst. On this

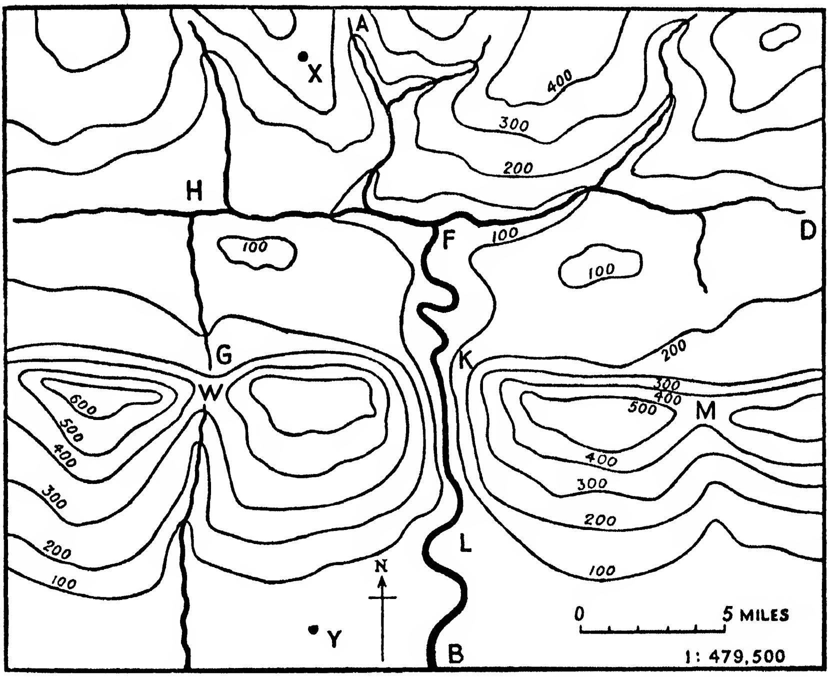


Fig. 15. A SCARPED RIDGE AND CLAY VALE.—Draw a section from X to Y.

sketch mark also (in red) Chichester, Arundel, Cocking, Midhurst, Petworth, and Pulborough. The finished drawing should be similar to, but larger than, Fig. 16.

The outstanding features of the map are now revealed in a simplified form. It is apparent that the surface features of the given map consist in the main of a central ridge of hilly country with a scarp slope to the north, and dip slope to the south. South of the ridge is a flat plain, and north of the ridge a wide east to west valley drained by the river Rother.

North of this valley the land begins to rise again. The ridge is broken by a water gap through which flows the R. Arun, and ten miles to the west of this gap is a wind gap south of Cocking. From this point a small stream flows north to Midhurst, while two miles south of the Cocking gap the river Lavant flows southwards to Chichester. At this point a comparison of these relief features with those on Fig. 14 would be profitable. Which of the rivers on the Chichester map may be termed consequent, subsequent, or obsequent?

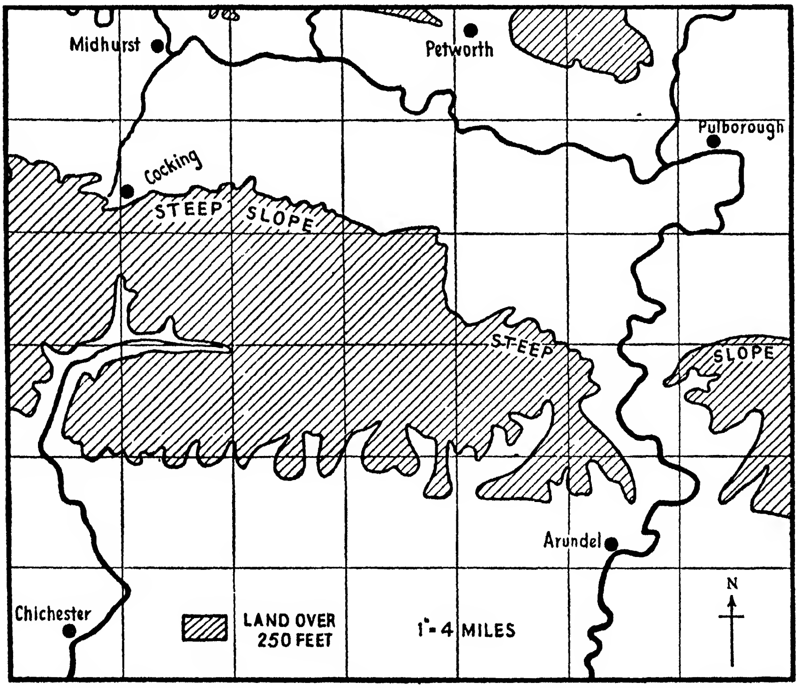


Fig. 16. DISTRIBUTION OF HIGHLAND AND LOWLAND.

Follow the Arun and Rother valley to the point where the 50 ft. contour crosses the stream (A3). Measure the length of the river from this point to the mouth of the Arun (the Arun enters the sea two miles beyond the southern limit of the map). From this data work out the gradient of the river between South Ambersham (A3) and the sea. This section of the river flows very slowly, hence the Arun meanders in great loops from Pulborough southwards. In the Arun Gap (D6 and E6) the river, on the outside of the meanders, has in

many places cut into the valley sides exposing white chalk cliffs, *e.g.* to the west of North Stoke where the contours form almost a semicircle. As a comparative exercise, work out the gradient of the R. Lavant south of West Dean. This stream flows more quickly than the R. Arun and does not meander so much. The Lavant south of West Dean is a very small stream, relative to the size of the valley through which it flows. Can you give the reason for this?

The central hilly district of the map, being part of the South Downs, is composed of chalk. Because chalk is a porous rock there is little surface drainage and many dry valleys (which may contain streams for a short period in rainy weather).

A simple diagrammatic section from the north to the south of the map is given in Fig. 17. To the south of the chalk hills is a fertile clay plain, while to the north is a plain composed of Gault Clay and Greensands.[1]

The Vegetation of the Map

There is little direct information given on the map concerning the vegetation of the region, but much may be deduced from other features and a knowledge of the rocks. A comparison of this map with the "Land Utilisation" map of the same area would be valuable.

The dark green regions are woodlands, coniferous or deciduous according to the trees indicated. The light green areas are parks. Other information may be deduced from the names of places, *e.g.* Oakwood House, Graffham Common, Downs Farm, etc.

The chalk hills to the west of the Arun Gap have many extensive woods of coniferous and deciduous trees. This is somewhat contrary to the generally accepted idea of a chalk downland, but here much of the chalk is covered with a layer of "clay with flints" which holds up the surface water and encourages tree growth. The chalk hills east of the Arun Gap are devoid of woodland. Here the porous chalk is at the surface, and there is a large area of typical grassy downland, a region eminently suitable for sheep rearing. South of the chalk hills are few woods, but a very large number of farms. This suggests that the original forest of the clay plain

[1] (See *British Isles*, Preece and Wood.)

(see Fig. 17) has been cleared because the land is fertile and very suitable for agriculture. It is a region of mixed farming, growing grain and fruits and rearing cattle for dairying.

Immediately north of the escarpment between Bepton (B1) and Graffham (B3) around Sutton and Bignor (C5) and east of Amberley (C6) is a narrow belt containing no woodland and many farms. This, too, is a region of agricultural wealth. The upper Greensand rocks, which here come to the surface, are rich farming lands. Here a considerable number of fields are used for the cultivation of wheat, barley, turnips, etc. The arable areas of this zone are marked brown on the " Land Utilisation " map of the region.

Immediately to the north of this belt is a region of rich pasture land associated with the heavy soils of the Gault Clay belt. Still further north, and to the south of the R. Rother, is a region where large areas of coniferous woodland still

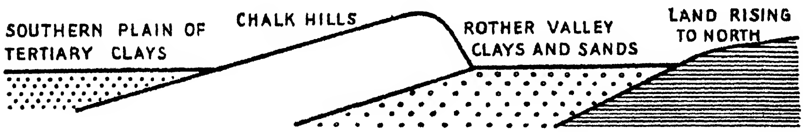


Fig. 17. A Diagrammatic Section Across the Map from South to North.

remain. Coniferous trees flourish on light sandy soils, and it is therefore to be assumed that in this region the soil is not sufficiently fertile to have encouraged the clearing of the natural woodland.

North of the R. Rother the soil is richer, for there again are fewer trees and more farms, primarily engaged in dairying.

The districts near the river from Pulborough southwards are badly drained, the frequent fine blue lines indicating drainage ditches. These districts are too wet and marshy for arable farming and are used as water meadows for cattle rearing. Many of the fields contain large patches of rushes.

The Distribution of Settlements

(A) Towns.—The most important towns on the map are Chichester, Arundel, Midhurst, and Petworth.

Chichester. Chichester (Cissa's fortress) is a cathedral city built on the site of a Roman settlement (Regnum). In the

Town Hall a Roman temple inscription is preserved, two of the churches are built on Roman foundations, and near the city is the site of a Roman amphitheatre. A careful study of the roads of the city shows a "ring" (coloured yellow) which is a road encircling the line of the city walls of Roman foundation. The main roads from north to south and east to west cross one another in the centre of the city to form a

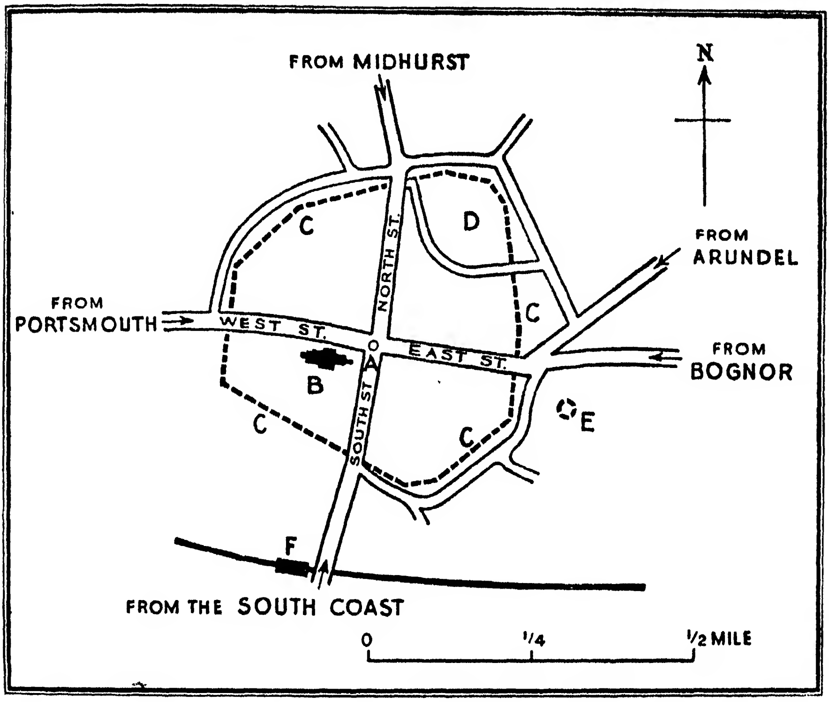


Fig. 18. PLAN OF CHICHESTER.—A. Carfax (cross roads) with old market cross. B. Cathedral. C. City walls of Roman foundation. D. Priory just within the walls. E. Site of Roman amphitheatre. F. Railway station outside walls (cf. Chester, York and Shrewsbury). Compare this diagram with the diagram of the site of Shrewsbury.

"Carfax" (Lat. *Quadrifurcus* = fourforked, cf. Fr. *carrefour*). Here at the junction of North, South, East, and West Streets stands a fine old market cross, and nearby is the cathedral (see Fig. 18). The occurrence of the market and church at the central cross roads is a common feature of many old market towns (*e.g.* Chester, Shrewsbury, Oxford) though in modern times the market may have been established on another site.

Chichester is situated where two natural routes cross : (*a*) the east to west route along the southern plain, and (*b*) the north to south route via the Lavant valley and the Cocking gap across the chalk hills to the north. This is the most important fact of its position both in Roman and modern times. Roads and railways follow these natural routes so that Chichester is an important nodal centre. Striking north-east from Chichester is the Roman road Stane Street, which can be followed, sometimes as a road, and sometimes as a footpath, as an extraordinarily straight line to beyond Pulborough (B7). That Chichester is a city of some regional importance is emphasised by the existence of a cathedral and a college. To-day its main function is as a route centre, and as a market centre for the surrounding agricultural lands.

Arundel. Like Chichester, Arundel is important because of its relation to natural routes. It is situated on the lower hill slopes above the badly drained land of the valley floor. At the southern entrance to the Arun water gap it controlled a natural route northwards between the south coast and London. For this reason it was fortified in Norman times to protect this route against possible invaders from the south. The site of Arundel Castle was suitable for defence because it rose above the surrounding lowland and because at this point the river flowed along the foot of the hills and acted as a natural moat.

Although there is a continuous route (road and footpath) through the Arun gap between Arundel and Amberley (C6) the main route northwards avoids the valley and keeps to the higher land. This is partly because of the marshiness of the valley and partly because of the number of bridges required. The railway has had to follow the valley, in spite of bridging and other difficulties, in order to avoid the steep gradients of the hills on either side. Arundel is a route centre of some importance, and acts as a market town for the surrounding country. Small sailing boats can reach Arundel from the sea.

Midhurst. Midhurst (hurst = wood) is a small market town. It is situated at the intersection of the east to west route along the Rother valley, and the north to south

route to Chichester via the Cocking gap. It is the limit of navigation on the Rother for small rowing boats and canoes.

Petworth. This is another small market town. Like Midhurst, it is situated where an east to west route crosses a north to south route. To the south runs a moderately easy route across the chalk hills to Chichester, while to the north the road follows a valley in the northern hills to Guildford and London.

(B) VILLAGES.—Draw another map similar to Fig. 16, and on it, square by square, mark all the villages (groups of houses with a church). The finished diagram will throw much light on the distribution of villages in relation to the relief. They fall into several groups—

(1) A line of villages to the north of the R. Rother, including Stedham (A1), Tillington (A4), Fittleworth (B6), etc. These settlements owe their existence to :—

(*a*) Fertile soils for farming.

(*b*) Easy east to west routes along the northern edge of the Rother valley.

(*c*) The control of minor routes northwards across the hill country beyond the northern limit of the map.

All these villages are linked by an important east to west main road.

(2) There is a second line of villages along the northern edge of the escarpment. These include Bepton (B1), Cocking (B2), Heyshott (B2), Graffham (B3), Sutton (C5), Bignor (C5), Bury (C6), and Amberley (C6). These villages owe their existence to :—

(*a*) The occurrence of rich farm lands, and

(*b*) Water supply.

South of these villages is the chalk country. Rain soaks through the porous rock until it reaches an impermeable layer. Along the junction of the permeable and impermeable rocks is a line of springs.[1]

The points where the small north-flowing tributaries of the Rother begin should be observed. These villages are linked only by minor roads and footpaths, but each is connected by

[1] (See section on springs, p. 129 and Fig. 69.)

a second class road with the main east to west road at the north of the map.

(3) South of the chalk hills on the southern plain there are a large number of villages due to the fertility of the land and the ease of obtaining water supplies.

(4) A fourth group of villages are those along the margins of the Arun gap, *e.g.* Houghton, N. Stoke, S. Stoke, etc. It will be noticed that all these villages are on the higher land near the valley sides above the level of the marshy valley floor (cf. Arundel).

(5) Another group of villages is to be found in the Lavant valley, *e.g.* West Dean, Singleton, and East Dean. Their position is primarily determined by their position on the north to south valley route, and their control of the lateral routes which enter the Lavant valley from the east and west. Water supplies would be obtained by boring through the chalk layers, which at this point (because of the lower elevation) will not be as thick as on the higher chalk lands.

Study Fig. 16 and find out how far it is true in this region that the large market towns tend to occur at intervals of about ten miles. Can you think of any possible reason for this?

It should be noted finally that the villages are essentially lowland settlements, seeking the fertile lowlands and avoiding the uplands. Only two villages, Upwaltham (C4) and Madehurst (D5) occur above a height of 250 ft.

Communications

Prepare another map similar to Fig. 16, and on it mark the following in addition to the rivers (in blue):—

(*a*) The main roads (in red), Chichester to Midhurst, Chichester to Arundel, Chichester to Petworth, Arundel to Pulborough, and Midhurst to Pulborough.

(*b*) The railways (in black), Chichester to Midhurst, Chichester to Arundel, Arundel to Pulborough, and Pulborough to Midhurst.

Ignoring the road from Chichester to Petworth, it will be observed that both the roads and railways are arranged in a definite rectangular pattern. Midhurst, Pulborough, Arundel,

and Chichester are at the four corners of the " communication rectangle." This is because of the strong control of the relief features on the routes. East to west routes (both rail and road) follow the north and south lowlands. North to south routes take advantage of the easiest routes across the escarpment.

In both the northern and southern lowlands the road and rail routes are some distance apart. In each region the railway route keeps to lower land than the road, in order to avoid gradients which would be too steep for a railway. The villages were linked by roads long before the period of railway building.

The study of the course of the rivers Rother and Arun reveals a number of old canals and locks (*e.g.* there are three locks in square A3). This suggests that at some period the river has been used for transport. Beyond the northern limits of the map is the Wealden Area, where, before the Industrial Revolution, there was a flourishing iron industry. This partly helps to account for the former importance of river transport. Can you suggest why?

Probably the most interesting feature of the communications shown on the map is the Roman road (Stane Street) which trends north-eastward from Chichester. It is used as a modern road as far as Warehead Farm (E3). At this point the modern road bends around Halnaker Hill to avoid the higher land. The Roman road, however, used to proceed direct to Seabeach, irrespective of the high ground which had to be crossed. Beyond Seabeach the course of the Roman road can be traced almost continuously to Pulborough and beyond, but large stretches of it have fallen into disuse and can only be followed as a footpath.

Exercises

1. Account for the fact that the railway station for Fittleworth (B6) and Petworth (A5) are so far removed from the villages.

2. Compare and contrast the road and railway routes between (*a*) Arundel and Pulborough; (*b*) Chichester and Cocking; (*c*) Chichester and Arundel. Account for the differences.

3. What difficulties are encountered on the main road between Slindon (E4) and Whiteways Lodge (D6)?

4. Account for the fact that so many of the roads of the chalk uplands are unfenced, while there are so few unfenced roads on the lowland areas.

5. Is there any section of a main road with a gradient steeper than 1 in 7 (consult characteristic sheet, opposite p. 5).

The Distribution of Population

Prepare another diagram similar to Fig. 16. On it mark:— (*a*) Each village (with a church) by a small square; (*b*) each hamlet (a group of houses without a church) by a small circle; (*c*) each farm by a small cross; (*d*) each isolated house by a dot (*e.g.* Nyton, F3).

The completed diagram will give a very good idea of the general distribution of population throughout the area. The following facts will be revealed:—

(1) The southern plain, a rich agricultural region, is densely peopled.

(2) The middle belt of highland is scantily populated. This is due to:—

(*a*) The prevalence of woodland.

(*b*) The large areas of chalk downs which are only suitable for sheep farming.

(*c*) The difficulty of obtaining supplies of water owing to the porous nature of the chalk.

(3) Within the middle belt of highland the Lavant valley and the Arun Gap are somewhat more densely populated.

(4) The broad vale north of the chalk escarpment is densely but not evenly populated. Population is densest along the northern and southern margins of the vale, and there is a middle zone (corresponding to the region of coniferous woodlands) with a less dense population. Even this, however, is not so scantily populated as the chalk hills.

(5) Square B7 and portions of squares C6 and C7 contain few people. Think of as many reasons as possible why this area is scantily populated.

Historical Remains and Evidence of Former Settlement

Prepare another map similar to Fig. 16. On it mark:—(1) in black, all Roman remains, including Stane Street; (2) in red, all tumuli and non-Roman camps and entrenchments (if any); (3) in blue, all other antiquities.

(1) The Roman remains consist of those at Chichester and a series of entrenchments and a camp in the neighbourhood of that city. These were part of the defensive system of the main Roman settlement at Chichester. There is another camp near Stane Street (B6). This camp, near the confluence of the Rother and Arun, guarded the routes southward via the Arun gap, and westwards up the Rother valley. The Roman villa in C5 is also near to Stane Street.

(2) The tumuli or burial mounds, and non-Roman camps and entrenchments are remains of the British period of occupation. The early inhabitants of Britain avoided the marshes and forests of the lowlands, therefore most British remains are found on the higher land. This is certainly true of the British remains shown on the specimen map. In D2 is a British camp occupying the summit of a small hill. British camps are nearly always to be found in such a position, and perhaps one of the most complete and well known is the British camp on the Malvern Hills. These camps usually consist of an embankment, or a concentric series of embankments, composed of rock and earth dug from encircling ditches.

British settlements were usually connected by tracks following the hill tops. Because of this they are often indicated as "Ridgeways." On the specimen map there is a ridgeway following the crest of the escarpment from Linch Down (B1) to Bishops' Ring (C4). Try to find other portions of this Ridgeway further east. Nearly all the tumuli marked on the map are near to this ancient track.

In some parts of Britain there are other evidences of the early British period, such as entrenchments (non-Roman) and stone circles such as Stonehenge. Stone circles are more commonly found in the highlands of Cornwall and Devon, the Welsh borderland, and the Lake District.

(3) There are not many indications of other historical remains on the map, and they consist of (*a*) castles at Amberley (C6) and Arundel (E6); (*b*) a priory (F6); (*c*) four remains

of what were probably Manor Houses, *e.g.* Drayton Manor House (F2). These remains are partly the result of the destruction of castles, religious foundations, and private property during the various periods of civil war in England. The mansion at Cowdray (A2) was accidentally destroyed by fire in 1793. At Arundel, the Norman castle on the hill is finely preserved and used as a residence, but there is a ruin of a Norman keep on the lower land by the river.

The Significance of Place Names

Some information concerning the history of a given region can often be deduced from the place names. Before the period of the Norman Conquest, Britain was invaded several times. The invaders left a lasting mark on the map of England in the form of the names they bestowed on the places where they settled. The most important groups of place names are those (*a*) of Celtic origin; (*b*) of Roman origin; (*c*) of Anglo-Saxon origin; (*d*) of Danish and Scandinavian origin; (*e*) of Norman origin.

(*a*) NAMES OF CELTIC ORIGIN.—These are chiefly associated with Ireland, Scotland, the Lake District, Wales, Cornwall, Devon, *i.e.* the mountainous areas of the north and west to which the original inhabitants of Britain were driven by the successive invasions. Typical names of Celtic origin differ according to the parts of Britain in which they are found. The following list gives some of the commonest of the Celtic forms (I, Irish; W, Welsh; S, Scottish; C, Cornish).

Aber (W), *mouth.*
Avon (W), *stream.*
Bal or Bally (I), *village, house,* or *farm.*
Ben (S), *a peak.*
Bod (W), *abode.*
Bryn (W), *hill.*
Caer or Car (W), *fort.*
Carrick (I), *cliff.*
Carig (W), *stones.*
Coed (W), *wood.*
Combe (C), *valley.*
Croes (W), *cross.*
Cwm (W), *valley.*
Dwfr (W), *water.*
Ferm (W), *farm.*
Fridd (W), *meadow.*
Glan (W), *shore* or *bank.*
Gwynn (W), *white.*
Galch (W), *lime.*
Hendre (W), *homestead.*
Inver (S), *mouth.*
Kil (S), *church.*
Knock (S), *hill.*
Llan (W), *church.*
Mawr (W), *big.*

Nant (W), *stream.*
Pant (W), *hollow.*
Pen (C), *peak* or *headland.*
Pistyll (W), *waterfall.*
Pont (W), *bridge.*
Rhos (W), *moor.*
Tor (C), *high rock.*
Ty (W), *house.*

(*b*) THE NAMES OF ROMAN ORIGIN.—These are almost entirely confined to the use of the word "chester" (L. *castra*, a camp) and its variations, *e.g.* "caster" as in Lancaster, "cester" as in Gloucester and Worcester, and "xeter" as in Exeter and Uttoxeter.

(*c*) NAMES OF ANGLO-SAXON [illegible].—Such names are widely distributed over the low[illegible] England and the lowlands of Scotland. They a[illegible]arly common in East Anglia and the southern [illegible] The following list gives some of the words which [illegible]ost frequently:—

Beck, *a rivulet.*
Bury, Burgh, Borough — *a fortified place.*
Dale, *a valley.*
Ham, *a house.*
Hurst, *a wood.*
[illegible]ng, *a field.*
Lea, *pasture.*
Marr, *a lake.*
Set, *settlement.*
Ton or Tun, *enclosure* or *village.*
Wick, *a village.*

(*d*) NAMES OF DANISH ORIGIN.—Such names are most frequently found in (1) East Anglia, Yorkshire, and Northumberland; (2) Westmorland, Lancashire, and Cheshire. The most characteristic Danish termination is "by"—a village or homestead, which is evident in such names as Whitby, Appleby, West Kirby, and Derby.

The following are examples of Danish words which occur most frequently:—

Beck, *a brook.*
By, *a farm* or *village.*
Carr, *marshy ground.*
Fell, *a hill.*
Force, *a spring.*
Gill, *a ravine.*
Holme, *an island.*
How, *a mound.*
Lythe, *a slope.*
Nab, *a peak.*
Rigg, *a ridge.*
Scarth, *a pass.*
Thorpe, *a village.*
Toft, *a field.*
Wath, *a ford.*
Wick, *a bay.*
With, *a wood.*

(*e*) Names of Norman Origin.—These are not of very frequent occurrence, but when they do occur they are easily recognisable, *e.g.* Beaulieu, Richmond, Beaufort, etc.

Exercise

Study the place names on the specimen map and try to deduce some information concerning the settlement of the region in pre-Norman times.

Genf' 'ontour Exercises

The drawing of c 's from given data.

(*a*) Read the de: refully two or three times until you can visualise wha 'red.

(*b*) Make a small ro n indicating where the chief features described will occur.

(*c*) Think out carefully how the rivers will be arranged, and draw these and their tributaries first. (This is most important if the finished map is to look like a possible piece of country.)

(*d*) Begin the contouring by drawing the lowest first and carrying it around the lower part of the rivers. Study the contouring on diagrams 8-14 and the contouring of selected O.S. maps in order to become familiar with the contour forms.

Draw contour maps of the following, taking care to insert a suitable scale, the numbers of the contours, and an arrow to indicate north:—

(1) A river valley with one tributary.

(2) A river valley with several tributaries.

(3) A lake surrounded by hilly country with all the rivers draining into the lake.

(4) A lake, long from east to west, lies in mountainous country. Rivers enter the lake on the north, east, and west; but on the south a stream flows from the lake, leaving it at a height of 300 ft.

(5) A plateau, 4 ml. long and 2 ml. broad, averages 1000 ft. in height. On the north it drops steeply to an undulating

plain about 300 ft. above sea-level, while in the south it falls gently to the coast.

(6) An island is 8 ml. long from north to south and 6 ml. wide. On it are two peaks, the one in the north being 1000 ft. high, and the one in the south 700 ft. The latter descends very steeply to the sea on the south. The col or pass betweer the two hills is between 300 ft. and 400 ft. above sea-leve On the N.W. is a tract of marshy lowland, while the west slopes of the northern hill are heavily wooded. In the S is a village X with a post office and a church with a s

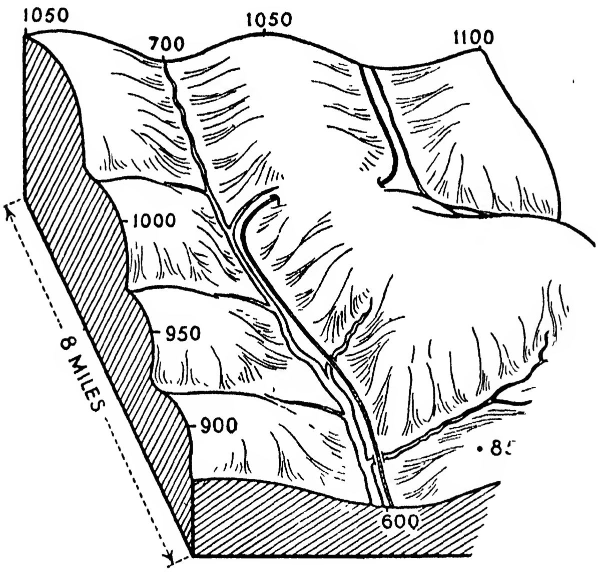


Fig. 19.

On the east coast is another village a church with a tower, and a lightl by road and railway.

(7) Draw a contoured sketch m tract of country which is 15 ml. from north to south. A range and with an average elevatior from west to east and pres north. It is separated fron which gradually narrows ea a bold promontory. The

gorge of a river which receives the drainage of an east to west stream separating these hills from the low plateau occupying the north of the area represented. This river has its headwaters in the plateau and enters the sea through the coastal plain.

(8) Draw a sketch map of the area shown on Fig. 19, ·sing contours at 50 ft. intervals.

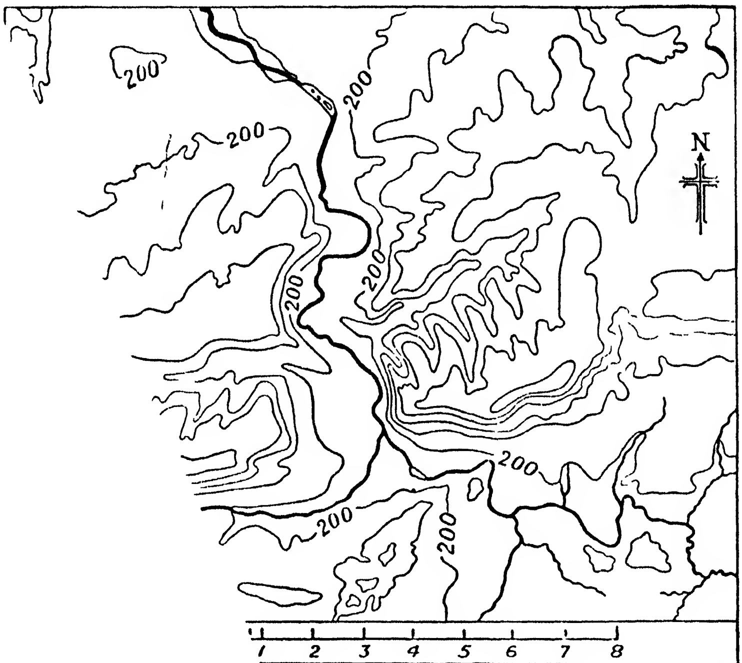


Fig. 20.

MAP EXERCISES

·n in Fig. 20. It is contoured at ·nd shows all the surface streams.

he map in square miles.

·han 600 ft. above sea-level.

" "escarpment," and "dry ·ces on the map.

of the relief of the land.

area, one from north to Insert them on the map.

(2) Describe the features associated with the river shown on the map (Fig. 20), and compare the character of the valley at different parts of its course.

(3) Compare the streams in the S.E. of Fig. 20 with that in the S.W., and make some comparison of the landscape likely to be seen in different parts of the region mapped.

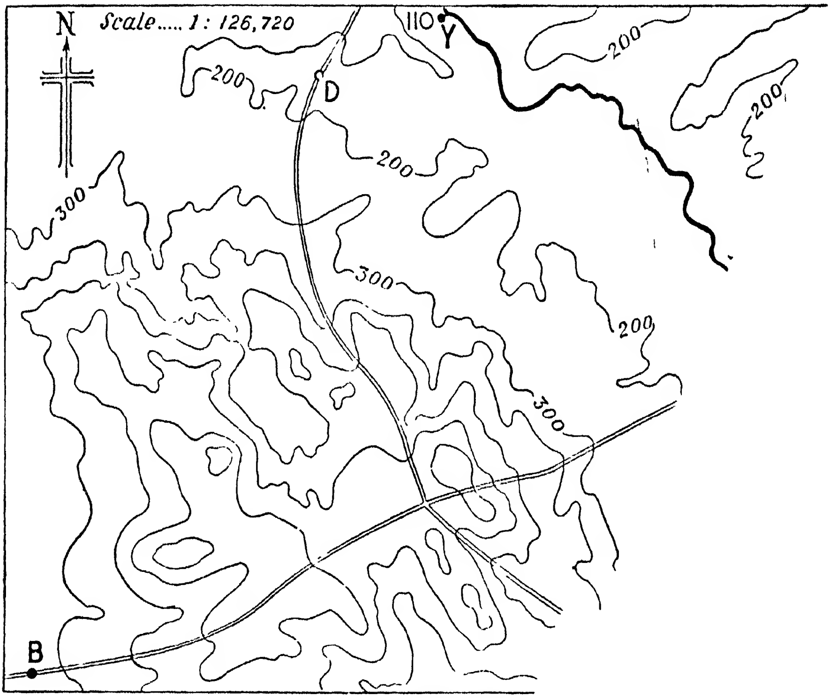


Fig. 21.

(4) Suggest where, on Fig. 20, not, likely. Suggest any negati' location of village sites, and say wh made of the land in the main vall

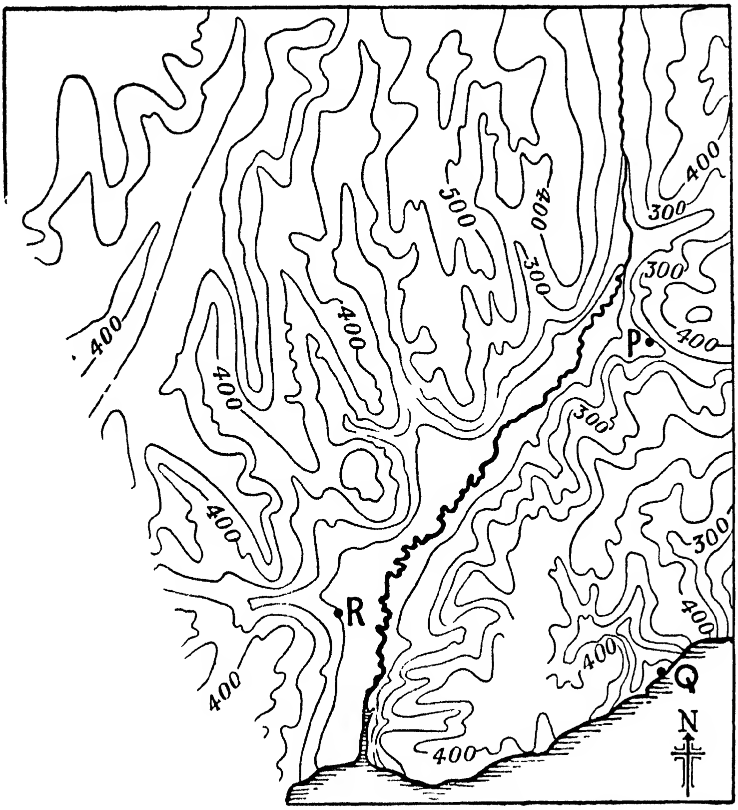
(5) Study the map (Fig. 21). 100 ft. The figures near X and the river at these points. Tw cross the region.

(*a*) Shade the parts over 8'

(*b*) Measure the distance average fall of the river e:

(*c*) In what *general* direction is the river flowing ?

(*d*) Describe *in detail* the course of the road from A to B. How does it differ from that of the road from C to D ?



ıle 1 : 126,720

22.

ief and write notes on the

ons.

(7) The map (Fig. 22) shows part of the south coast of England. The contours are drawn from sea-level at 100 ft. intervals. Examine the contours carefully and the positions of the points P, Q, R, and S.

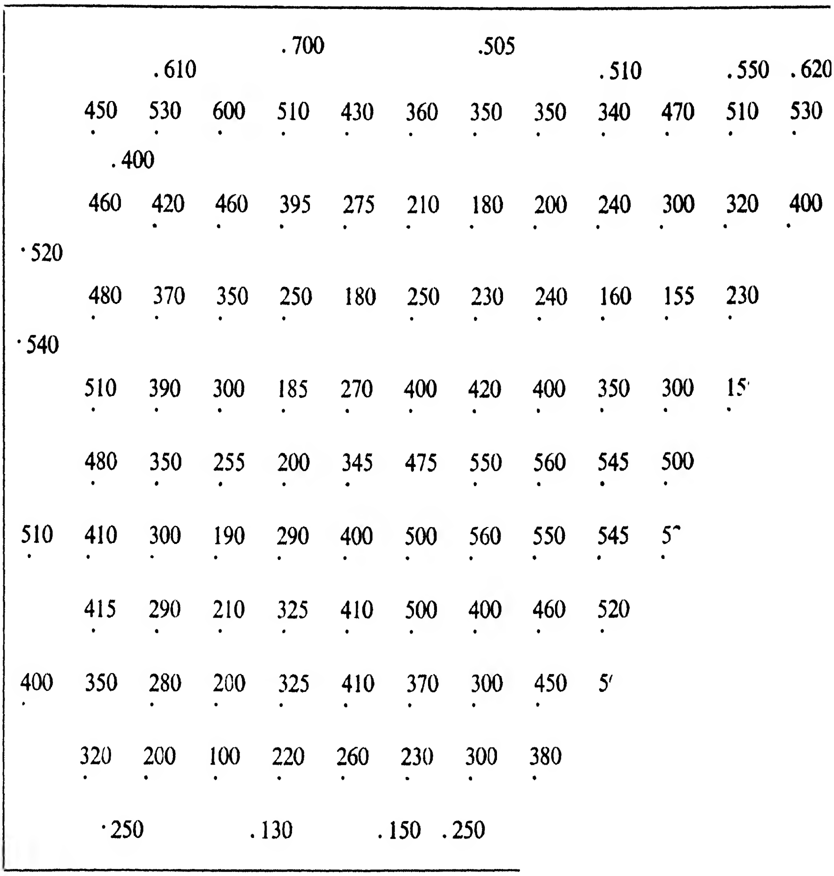


Fig. 23.

(*a*) Shade the areas which are 6

(*b*) On the ruled lines draw a along the line joining S and P

(*c*) Draw two right-banl

(*d*) Show the most li' through R to S, and ma

(*e*) Show the watershed in the south-eastern portion of the map (south of P).

(8) The numbers on Fig. 23 represent spot heights.

Insert the contour lines at intervals of 100 ft. (In this type of exercise it is advisable to commence by inserting the highest contour.)

CHAPTER II

THE EARTH AS A PLANET

The World in Space

People in ancient times believed that the earth was the centre of the universe, and that the sun and stars revolved around it. As the study of Astronomy grew, this idea was proved to be wrong, and for a long time it was thought that the sun was the centre of the universe. Modern knowledge, however, has revealed that the sun, while being the centre of the planetary system, is really one of a large number of suns, each with attendant planets, which make up the myriads of stars visible on a clear night. Away out in space, thousands of millions of miles beyond the distant stars of our group (known as the Galactic System, from Galaxy—the Milk Way), are millions of similar groups of stars. These gro are known to astronomers as Nebulae, and each ne

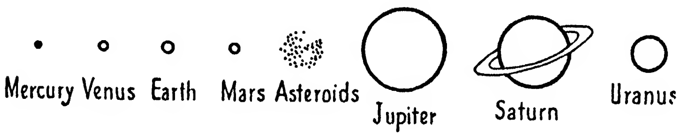


Fig. 24. THE PLANETS.—Mercury is nearest to the S farthest from the Sun.

contains in turn millions of suns, most of whi planets or satellites. According to the gr Arthur Eddington, there must be at million million suns in the universe. Wh fraction of the whole universe our plan

The Planetary System

The Planetary System consists which with their attendant moon moons in turn each revolve ar and while the earth only has each have nine.) The path orbit, and the orbits of trically with the sun as t

sun, then come in turn Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, and Pluto (see Fig. 24). Pluto, the smallest, was only discovered in 1930. Although the Planetary System is such a small part of the universe, the distances within it are immense according to our ideas. It would take a swift aeroplane about 56 years to travel from the earth to the sun, and 10,000 years, flying night and day, to cross from one side of Pluto's orbit to the other. Spacious as the earth may seem to us, if we represent it by a tennis ball, the sun would occupy a volume equivalent to that of four average classrooms. You may wonder whether life similar to that on the earth exists on the other planets. Venus and Mercury, nearer the sun, are too hot for such life, and the outer planets are too cold. Even Mars is somewhat chilly, and scientists have, as yet, no definite proof that life exists thereon.

'he Shape of the Earth

nother misconception of early peoples was the idea
'he earth was flat. To-day, we know that the earth is
y spherical, but instead of being flattened at both poles
orange, it is rather more like the shape of a pear,
ttened at the North Pole and on those portions
'ing to the S. Atlantic, S. Pacific, and Indian
page 87). The amount of the flattening of the
small. On a 16 in. globe the extent of the
'd be represented by the thickness of a sheet
'arth is often referred to as a "geoid"—a
means "earth-shaped."

's Shape

of reasons for the belief that the earth

t the sun would rise and set at the
countries. As we know, the times
in different parts of the world.
earth.

netrical shapes that appear to
are observed. The sun,
appear to be circular

in outline. We can therefore conclude that they are spherical in shape. Why should the earth be the only exception?

(3) The shadow of the earth always has a circular edge. This can be noticed by observation of the earth's shadow on the moon during eclipses. If the earth were a disc, then at times, if it were rotated, its shadow would be elongated or oval.

(4) Viewed from the deck of a ship at sea, the horizon appears to be circular, and if one climbs the rigging the expanse of visible sea greatly increases, but the horizon still remains circular. This is apparent from Fig. 25.

(5) An observer on a cliff watching the approach of a ship sees first the smoke, then the funnels, and lastly the hull. If the earth were flat the whole of the ship would be seen all

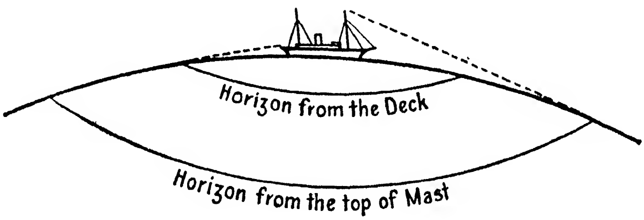


Fig. 25. To Show that the Expanse of Visible Sea Increases with Height.

the time, even though at first it was so distant as to be only visible through a telescope.

(6) An experiment was made on the Bedford Level Canal, the surface of the water providing a horizontal level. Three vertical stakes rising to equal heights above the surface of the canal were set in the ground at intervals of three miles (see Fig. 26), and an observer looked through a telescope in such a way that the top of stake A appeared to be level with the top of stake B. It was found that this line of vision A
instead of passing through the top of stake C, cut it at a po
about 6 ft. below the top. This could not happen if
surface of the earth were flat. Similar experiments in
localities give the same result.

(7) Finally, we know that we can travel *rou*
various directions, and come back to the st

The Size of the Earth and the Method of Locating Places thereon

For many purposes it is useful to remember that the circumference of the earth is 25,000 miles, and that the diameter is about 8000 miles. Actually the equatorial diameter is 7926 miles, and the polar diameter is slightly shorter, viz. 7900 miles, due to the flattening of the North Polar area.

In order to fix the position of places on the sphere, imaginary lines of reference are used. These are lines of *latitude* and *longitude.* Lines of longitude run north and south, and are all complete circles of the same size passing through both Poles. Lines of latitude are at right angles to lines of longitude and run east and west. The line of latitude which is exactly halfway between the Poles is called the equator (0°), and all

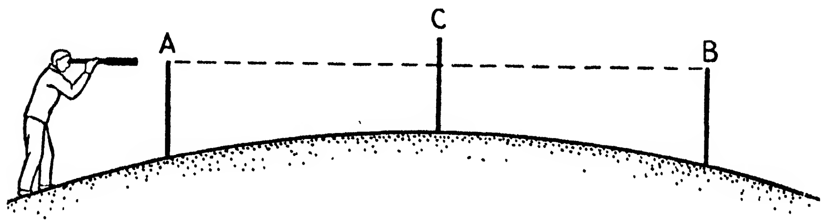


Fig. 26. To Illustrate One Method of Calculating the Curvature of the Earth.

the other lines of latitude are parallel to it; thus we speak of the parallels of latitude.

The equator and the lines of longitude are all *Great Circles.* A Great Circle is a circle drawn on the earth in such a way that its centre is also the centre of the earth. In other words, if the earth were divided into two by cutting along the plane of a great circle, then the two portions would be exactly equal, *i.e.* hemispheres. From the foregoing it will be clear that lines of latitude (except the equator) are not great circles. The *shortest line* joining any two points on a sphere is part of ·e circumference of the great circle passing through those points. (This can be proved by marking two points on pulling a piece of string tightly between them, and ng the string around the globe. The shortest tween any two places on the earth's surface the line of the great circle.

(*a*) LONGITUDE.—Lines of longitude are usually spoken of as meridians, the word "meridian" being derived from a Latin word meaning "midday." All places on the same meridian of longitude have midday at the same time. Study Fig. 27. Let EYXQ be a circle around the earth halfway between the two Poles. This circle is called the equator, and as it is a circle it can be divided into 360 degrees. Let C be the centre of the earth, and suppose that the angle YCX contains 20°. Then if NXS is line of longitude 0°, line NYS must be line of longitude 20° W., since it is west of NXS by 20°. Thus it will be seen that 360 lines of longitude can be drawn, all one degree apart. Each line will be a half-circle terminating in the poles. The one which passes through Greenwich we call the Prime Meridian, and is numbered 0°. The half-circle immediately opposite to this one (on the other side of the world) is 180°. The other lines of longitude are numbered east and west of the zero meridian up to 180°. 180° E. and 180° W. are one and the same line of longitude.

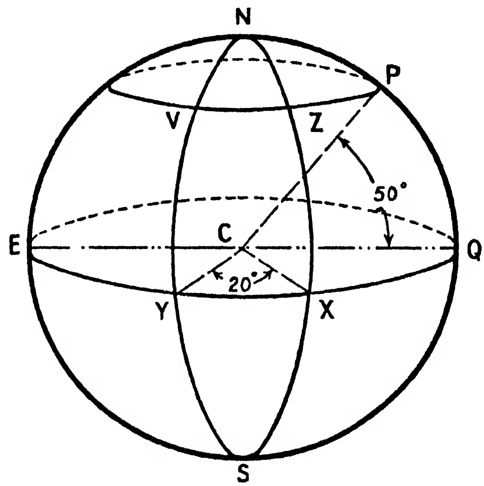


Fig. 27. LATITUDE AND LONGITUDE.

(*b*) LATITUDE.—Lines of latitude are circles drawn round the earth parallel to the equator. Suppose (Fig. 27) PZV be any one such circle. Then if the angle PCQ is 50° this line of latitude is 50° N., and P, on it, is 50° N. of the equator. Since the arc NX is one quarter of a circle that goes right round the earth through the poles, it follows that NX will represent 90° of latitude. Therefore eighty-nine circles of latitude can drawn parallel to the equator (and to one another) and degree apart. The ninetieth circle would merel the North Pole, whose latitude is 90° N. Simila of the South Pole is 90° S. The equator is latit

By reference to lines of latitude and longitude we can fix exactly the position of all places on the earth's surface. In Fig. 27 the point V is where latitude 50° N. crosses longitude 20° W., and as this is the only point at which they intersect it follows that 50° N., 20° W. is the position of one place only. Thus the position of point V is fixed.

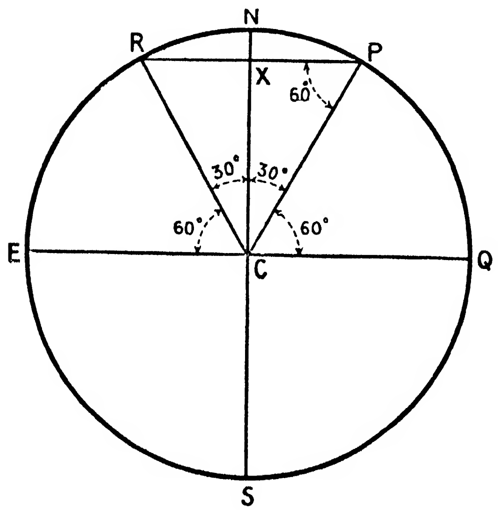


Fig. 28. To Show that Line of Latitude 60°N. is Half the Length of the Equator.

Let P be a point in Lat. 60°N.
Then ∠ PCQ = 60° and ∠ RCE = 60°.
∴ ∠ RCP = 180° − 60° − 60° = 60° also.
∵ RP is ll$^{\mathrm{e}}$ to EQ
∠ RPC = 60° and ∠ PRC = 60°.
∴ △ RPC is equilateral,
i.e. ∴ RP = PC = CQ = ½ EQ.

But RP is the diameter of the circle for 60° and EQ is the diameter for the circle of the equator. Since the diameter RP is half EQ it follows that 60° north is half the length of the Equator, and that a degree at 60° N. will be half the length of a degree at the Equator.

Notice that *Z* is on longitude 0° and V is on 20° W., therefore V and *Z* are 20° apart. X and Y are also 20° apart, but VZ is shorter than XY. This is because the lines of longitude approach more closely to one another as they near the poles. Hence the distance between any two meridians at the equator is greater than the distance between the same two meridians in latitude 50° N. Degrees of longitude decrease in size from the equator to the pole. At 60° N. a degree of longitude is exactly half the length of a degree at the equator (Fig. 28). It is clear from this that we cannot refer to longitude as ' 'tance in miles east or west of the Greenwich meridian. ıs angular distance, *i.e.* distance measured by angles which ·v different from distance measured in miles, yards, etc. · ·titude, on the other hand, are practically the apart, and since the whole distance round the ·ented by 360° and the actual distance is 25,000

miles, it follows that one degree of latitude is everywhere 25,000 ÷ 360 miles, or about 69·4 miles. There are sixty minutes to the degree, and sixty seconds in one minute (these minutes and seconds have nothing to do with those of time). 24° 50′ 20″ N. means that a place is 24 degrees 50 minutes 20 seconds north of the equator.

The Movements of the Earth and their Results

The earth moves in two ways. Firstly it *rotates* on its axis, making one complete rotation in twenty-four hours. This movement causes *day* and *night*. Secondly it *revolves* around the sun, making one complete revolution in approximately 365¼ days. Its path of revolution is known as its

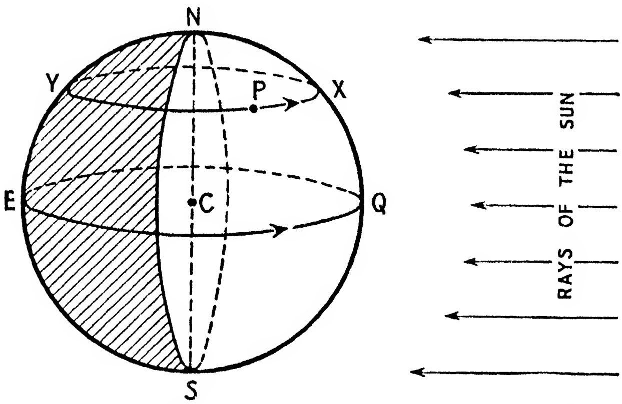


Fig. 29. DAY AND NIGHT.—Showing that all places have days and nights of equal length at the Equinoxes.

orbit. The plane surface in which it moves is called the "Plane of the Ecliptic." The earth's axis is not perpendicular to this plane, but is inclined at an angle of 66½ degrees to it. The inclination of the earth in relation to the plane of its orbit is shown on Fig. 30.

Perhaps you will have noticed that globes are always made so that the line joining the North and South Poles is not vertical. The revolution of the earth around the sun and the inclination of the axis together:—

(*a*) Fix the Tropics and the Arctic and Antarctic Circles.

(*b*) Are responsible for the change of the seasons.

(*c*) Cause the *varying* lengths of day and night.

The Effect of the Earth's Rotation

DAY AND NIGHT.—The diagram (Fig. 29) on page 51 shows how the rotation of the earth causes day and night. The earth rotates on its axis NS, moving in the direction of the arrow from west to east. It is clear that only one-half of the globe can receive the rays of the sun at any given moment, and that the other half must be in darkness. A place P rotates round the circle PXY once in twenty-four hours, and it is obvious from the diagram that its journey will be partly through daylight and partly through darkness.

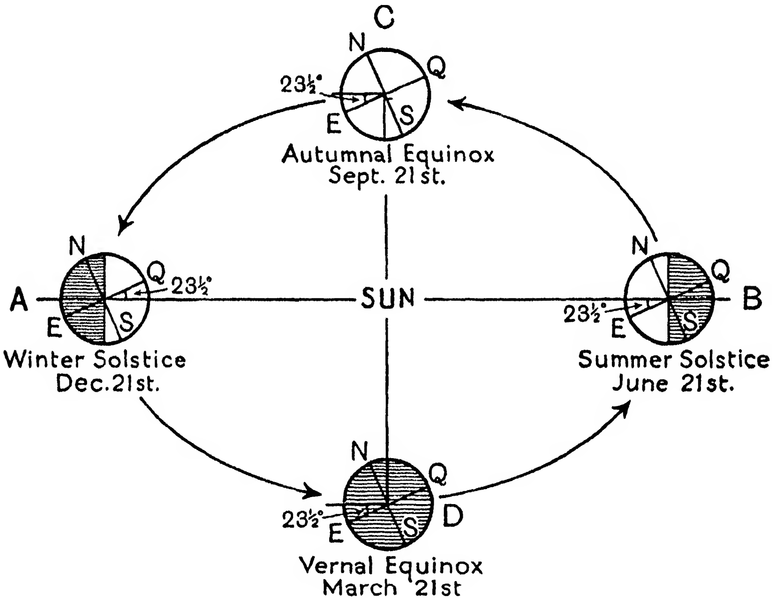


Fig. 30. THE SEASONS.

The Effects of the Earth's Revolution

(*a*) THE TROPICS.—The varying positions of the earth from season to season cannot clearly be shown on a flat surface, but Fig. 30 will give an idea of the position of the earth on four days of the year. It will be seen that on September 21st and March 21st the sun is vertically overhead (at noon) at the equator. These days are termed the *equinoxes* (Latin *Aequus*, equal; *Nox*, night), because, as will be shown later, all parts of the world have equal day and equal night, *i.e.* 12 hours daylight and 12 hours darkness.

move to its present position from the time when B was situated where A now is. The time at B is 4 minutes past twelve (noon). If C is 15° E. of A, then it is 1 hour since C experienced the overhead sun, *i.e.* the time is 1 p.m. Similarly, if D is 1° W. of A it will be 4 minutes before D reaches the position A, and the time at D is 4 minutes to twelve (noon). If E is 15° W. of A, then the time at E is 11 a.m. The time at X is midnight; the time at *Z* (90° E.) is 6 p.m.; and the time at Y (90° W.) is 6 a.m.

The sun is overhead for all places on the same line of longitude at the same time. Lines of longitude are " Midday " lines or *meridians* (Latin *Meridies*, midday). As the sun cannot be overhead at two meridians at once, it follows that " Local " time as measured from the noon of the overhead sun must vary from place to place. There will be a difference of two minutes between the local time of your town and that of a town about 20 miles east or west of it. Imagine what confusion it would cause if every town and village kept its own time, and clocks and watches had to be constantly altered as one travelled from place to place. To eliminate this confusion the world is divided into Standard Time Belts, each varying by 1 hour, and being roughly 15° in width. In England we take our time (Greenwich Mean Time) from the meridian 0° which passes through Greenwich observatory. This meridian is known as the Prime Meridian, and is used as a basis for the reckoning of international time. The standard times of various countries in relation to noon at Greenwich are given in *Whitaker's Almanack*.

On long sea voyages clocks are adjusted daily according to the position of the ship. In connection with the variation of time through the world, it is interesting to note that on Christmas afternoon, during the " Round the World " broadcasts, the Australian announcer is speaking in the early hours of Boxing Day morning. The close of play scores of a test match at Sydney are known in England on the morning of the same day, for when play finishes in Sydney at 6 p.m. it is only 8 a.m. in England.

The Date Line

A peculiar position arises at the meridian 180°. This meridian may be reckoned both as 180° E. and 180° W.

Study Fig. 42. If the time at A on the Greenwich meridian is 8 a.m. on Wednesday, December 9th, then calculating *eastwards* the time at C (179° E.) will be 7.56 p.m., Wednesday, December 9th; but if the time is calculated *westwards* it will be 8.4 p.m. Tuesday, December 8th, at D (179° W.). Allow 4 minutes more for 1° westwards from D and eastwards from C, and we discover that the time *at B* is both 8 p.m., Wednesday, December 9th, and 8 p.m., Tuesday, December 8th. This confusion of days must be corrected. A ship sailing eastwards through AXBY reaches B on Wednesday, but having passed B it is Tuesday, and the following day is again Wednesday. Ships sailing eastwards therefore gain a day, and the passengers have an "Eight-Day" week, the day following Wednesday being called Wednesday. Ships sailing westwards AYBX reach B on Tuesday, and having passed B it is Wednesday. Therefore westward bound ships miss a

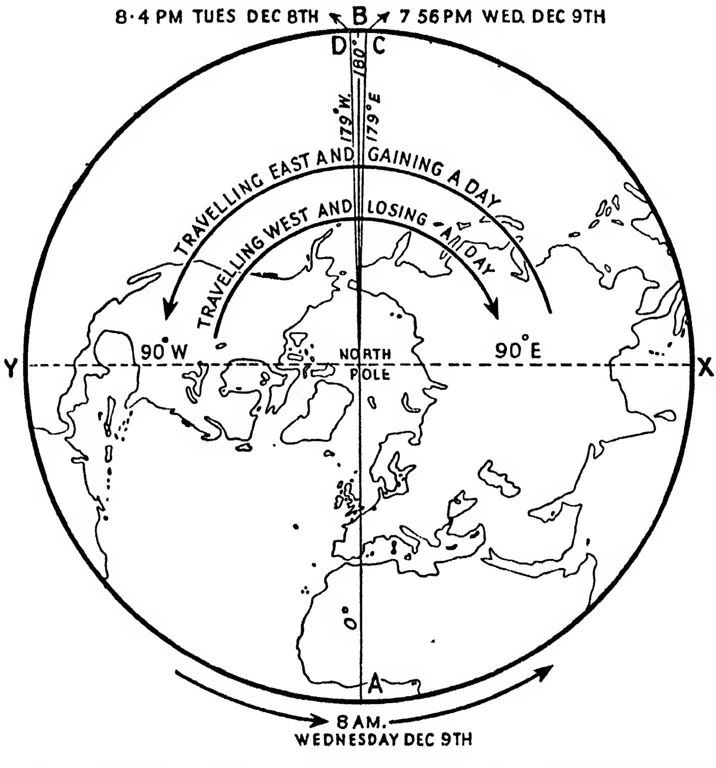


Fig. 42. To Show Why a Day is Gained or Lost When Crossing the Date Line.

day from the calendar, and the passengers have a "Six-Day" week, the day following Tuesday being called Thursday. Perhaps a "slang" reference may help you to remember this arrangement, viz. if we travel *west* a day "*goes west.*" If the date line (or the line where the date is changed) followed 180° exactly it would pass through groups of islands and cause confusion between one island and another. Therefore the Date Line zig-zags to avoid various groups of islands (Fig. 43).

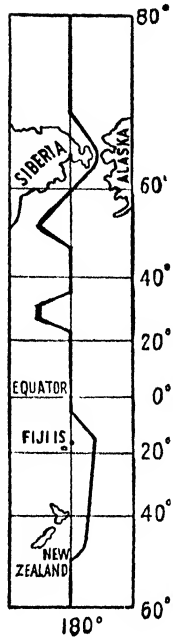


Fig. 43. THE DATE LINE.

It curves east of 180° in the Bering Straits between Siberia and Alaska; further south it bends to the west of 180° so as to avoid cutting through the Aleutian Islands. Thus the dates in Siberia and Alaska differ, *i.e.* if it is July 14th in Siberia it is July 13th in Alaska. Longitude 180° cuts through one of the Fiji islands and there would be considerable inconvenience if two parts of the same island had different dates. Therefore in the southern hemisphere the date line bends eastward around the Fiji and Tuga Islands. These islands, together with the Kermade and Chatham Island keep the same date as New Zealand.

CHAPTER III

THE BUILDING OF THE CONTINENTS

The Earth's Covering

The earth is composed of an inner core—probably solid throughout and certainly very hot—and an outer crust averaging 40-50 miles in thickness. It is now thought that the composition of the crust is not uniform, but that the continents are composed of less dense substances " floating " on a layer of a denser and heavier material which underlies both the continents and the oceans (see Fig. 44). An interesting feature of the map of the world is the general resemblance of the eastern and western shores of the North and South Atlantic oceans. It is easy to imagine that if the Americas were pushed eastwards they would fit roughly into the coastline of Europe and Africa—somewhat like fitting two pieces of a jigsaw puzzle together. This is the most obvious example of such parallel coasts of similar shape, but with a little careful study others will be found, viz. (1) among the islands which lie north of Canada, and (2) Madagascar and Eastern Africa. A noted scientist, Wegener, has used these facts, with others, as the basis of a theory of "Continental Drift." Briefly, this means that land masses which were once joined have drifted or " floated " apart.

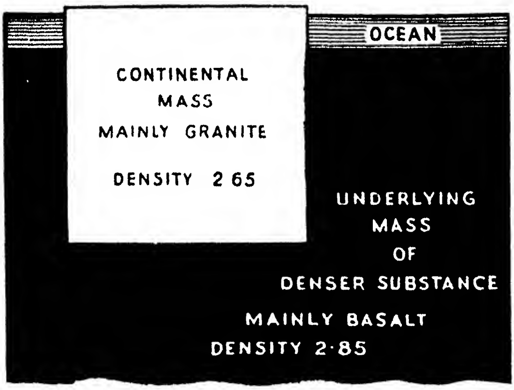


Fig. 44. Diagram to Illustrate the Conception of Floating Continents.*

Another theory supposed that all the areas shaded obliquely in Fig. 45 were continuous and formed a continent which scientists called Gondwanaland. Some geologists are of the

* *Earth Lore* by Prof. S. J. Shand. Thomas Murby & Co.

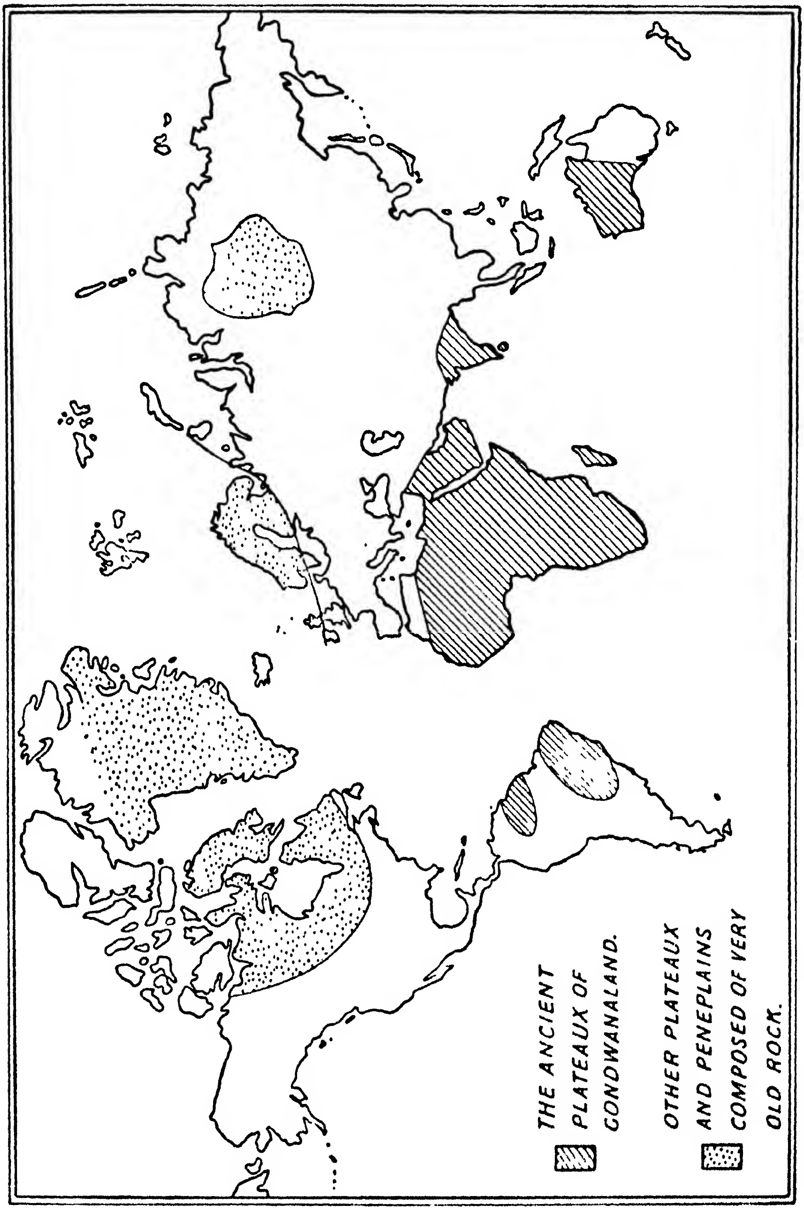

THE ANCIENT PLATEAUX OF GONDWANALAND.
OTHER PLATEAUX AND PENEPLAINS COMPOSED OF VERY OLD ROCK.

Fig. 45.

opinion that this continent broke up and portions sank, leaving widely separated areas of similar structure. Wegener, however, suggests that they were once joined but have drifted apart.

Broadly speaking, it will be seen that Wegener assumed that there are two principal groups of rocks forming the earth's crust, the continental masses being composed of relatively light rock, while their foundations and the floors of the oceans are made of rocks which are heavier. Within these two main groups there must be a great variety of rocks but scientists are unable to obtain samples of the rocks beneath the ocean floor. At the surface of the continents, however, geologists have obtained specimens of a wide range of rocks which have been classified in a manner similar to that described in the following pages.

THE PRINCIPAL CLASSES OF ROCKS

The earth's crust is composed of rocks. The term " rocks " includes not only the hard compact masses which may be seen in mountainous areas or in stone quarries, but also the finely disintegrated materials such as sand and soil. The study of rocks is known as Geology, and a knowledge of simple geological terms and of the chief classes of rocks is essential to the understanding of some branches of geography. Mainly according to the mode of their formation and their appearance, rocks may be classified as follows:—

(1) Sedimentary or Stratified Rocks.

(2) Non-Sedimentary or Unstratified Rocks.

- (*a*) Igneous Rocks;
- (*b*) Metamorphic Rocks.

Sedimentary Rocks

A river in flood has a dirty appearance due to the load of soil (gathered further upstream) which the river is carrying. As long as the current is rapid this load of fine soil or *silt* is carried in suspension, but when the speed is checked the silt is deposited. The rapid rate of flow is most effectively slackened when the river enters the sea, and a *layer* of silt is spread out over the sea floor. Gradually throughout long ages, this silt accumulates, layer by layer, until there is a

Canadian Pacific Photograph

TAKKAKAW FALLS IN THE CANADIAN ROCKIES.

You will observe that these mountains are built up of layers of stratified rocks. The tributary valley descends to the main stream by a waterfall, *i.e.* it is a hanging valley. Note the presence of large accumulations of broken material at the foot of the steep valley side and that the tributary valley is partially occupied by a glacier.

thick deposit, the weight of which compresses the lower layers into a hard rock. The pressure of the upper layers is not the only cause of the hardening, usually there is also a slow infiltration of some substance which acts as a kind of cement, binding together the grains into a compact mass. With very few exceptions all sedimentary rocks have been formed by the deposition of sediment under water, and they all have a characteristic "layered" formation. The layers are known as strata, and the rocks are said to be *stratified.* The stratification of rocks is often to be clearly seen in a railway cutting or in a quarry. This process of rock formation has been going on since the earth had a solid crust, probably about 500 million years ago.

During these long ages many different kinds of sedimentary rocks have been formed. Provided that the strata have remained undisturbed it will be clear that the bottom layers are older than the layers immediately above them. Geologists use this fact to ascertain the relative ages of rocks and to classify them as "old" or "new." The distribution of land and sea has undergone many and widespread changes, and certain portions of the earth's surface, *e.g.* the Limestone Alps and the Rockies of British Columbia, must once have lain fathoms below the surface of the ocean far from any coastline. Other areas which were once dry land are now submerged, *e.g.* the narrow seas around Great Britain were once dry land. It is largely through the study of the character of the sedimentary rocks that scientists can reveal the story of the changes during past ages.

Sedimentary rocks formed as described above by the *deposition of land derived materials* are usually various types of sandstones (hardened sands), clays, or shales (hardened muds) (Fig. 46). In addition, sedimentary rocks may be formed by the deposition on the sea floor of the *remains of microscopic sea plants or animals.* These organisms have the power of extracting calcium carbonate from the sea water and using it to build up their "skeletons" or shells. (Oysters, mussels, cockles, etc., also do this to construct their shells.) When the "organism" dies the skeleton falls slowly to the ocean bottom. The principal rocks formed in this way are chalk and limestone. In many limestones it is easy to see the remains of small shells, etc., without the aid of a microscope.

Lastly, one group of sedimentary rocks is formed by the depression beneath the sea of *large areas of dense swamp vegetation and forests.* In time layers of sand, silt, etc., are deposited above, and the vegetation is compressed into coal. The effect of the increasing pressure is to alter the plant remains both in composition and in appearance. A compact black mass is formed which is made up chiefly of carbon, and no trace of plant structure is visible to the naked eye. Some people believe that peat represents the first stage in the conversion of vegetation into coal, while lignite, or brown coal, which is found extensively in Europe and North America, represents a more advanced stage. If the pressure applied during formation has been greater than in the formation of ordinary coal, a highly mineralised form of coal containing a

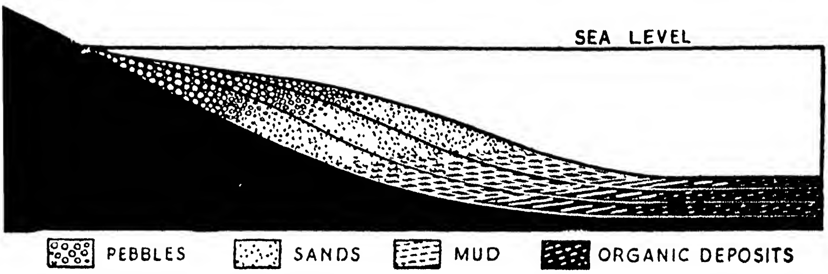


Fig. 46. THE DEPOSITION OF LAND-DERIVED MATERIAL ON THE FLOOR OF THE SEA.

high percentage of carbon is formed. This is known as *anthracite*, or smokeless coal. Still greater pressure, resulting in the expulsion of everything but the carbon, results in the formation of *graphite*, which is commonly used for the making of "lead" pencils, but which also has a number of industrial uses.

Some rocks, which are classified as sedimentary, may not, according to modern authorities, have been formed under water. Opinions differ as to the origin of the sandstone rocks which can be seen in the Midlands of England, Cheshire, etc. It is possible that they are compressed desert sands—such as the sands of the Sahara. In North China there is a sedimentary rock covering thousands of square miles, called *loess*, which may never have been under water, but was deposited by the dust-laden winds blowing outwards from the deserts of Central Asia.

Non-Sedimentary Rocks, or Unstratified Rocks

As their name suggests these rocks have not been formed by sedimentation, and are not characterised by a layered or stratified appearance. They fall into two groups, viz. (*a*) Igneous rocks; (*b*) Metamorphic rocks.

(*a*) IGNEOUS ROCKS (Latin *Ignis*, fire).—Igneous rocks include all those rocks which have been formed by the cooling of molten rock. The origin of such material is beneath the earth's crust. If, as a result of volcanic action, molten rock reaches the earth's surface, it cools relatively quickly to form volcanic rocks (Fig. 47). Many are glassy in appearance, and others, like basalt, are finely crystalline. Two well-known examples are basalt and andesite. The Giant's

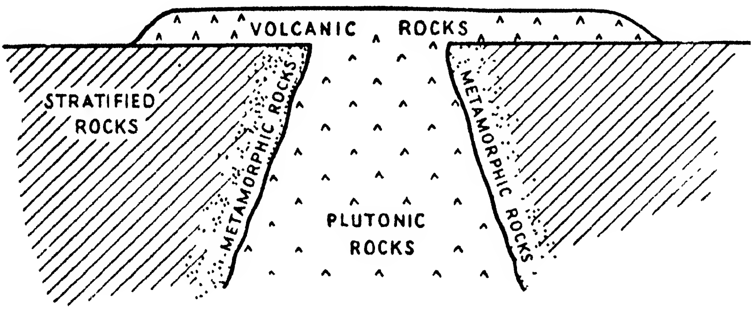


Fig. 47.

Causeway in North Ireland is a familiar example of *basaltic* rock, which splits naturally at angles of 120° to form six-sided columns.

If, however, lavas cool slowly at some depth below the earth's surface (Fig. 47) they are known as *plutonic*. The principal example of such rocks is *granite*, distinguishable by its large crystals, which are the result of slow cooling.

(*b*) METAMORPHIC ROCKS (Greek *Metamorphosis*, change).—Metamorphic rocks are those which, as a result of subjection to intense heat or pressure (Fig. 47) have changed from their former state. Originally, they may have been igneous or sedimentary rocks. Owing to heat and pressure, sedimentary rocks often become crystalline in appearance, and are sometimes difficult to distinguish from igneous rocks. By the

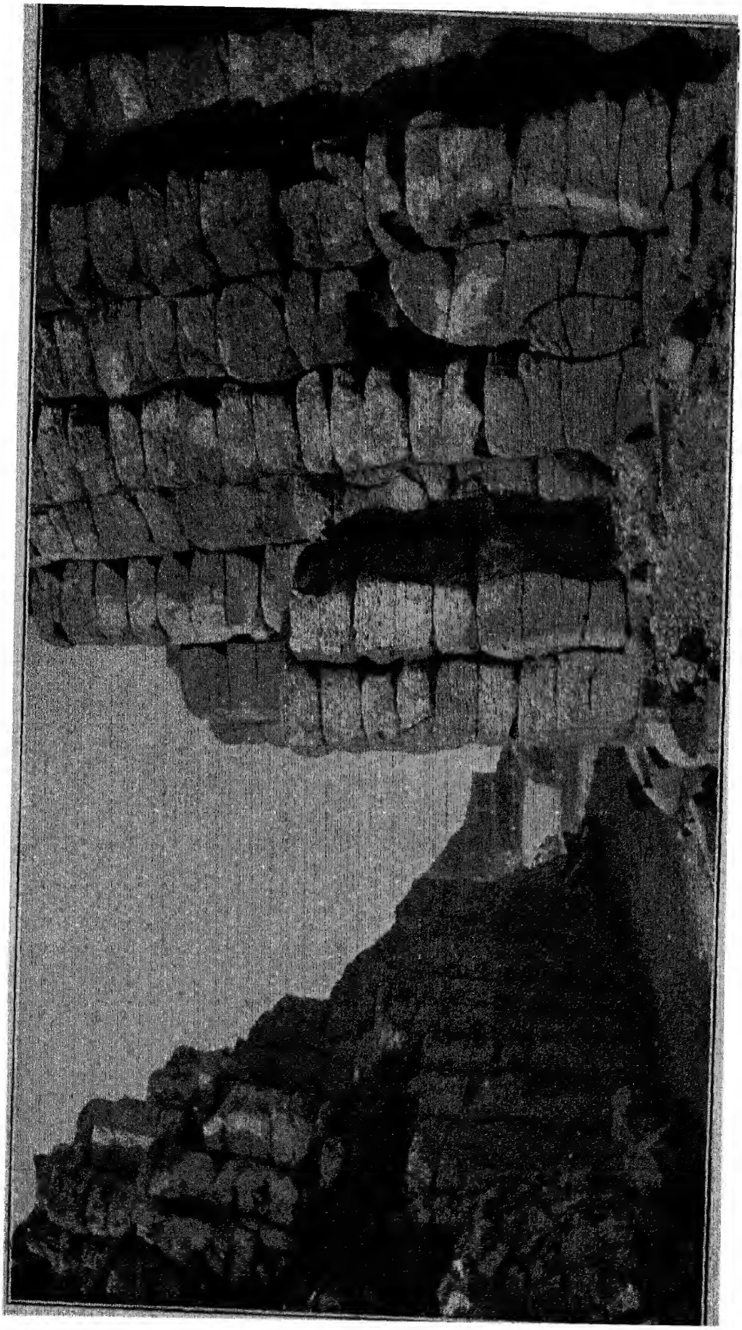


Photo by Valentine, Dundee

GIANT'S CAUSEWAY, NORTHERN IRELAND.

The picture shows the columns of basalt which are usually six-sided (hexagonal).

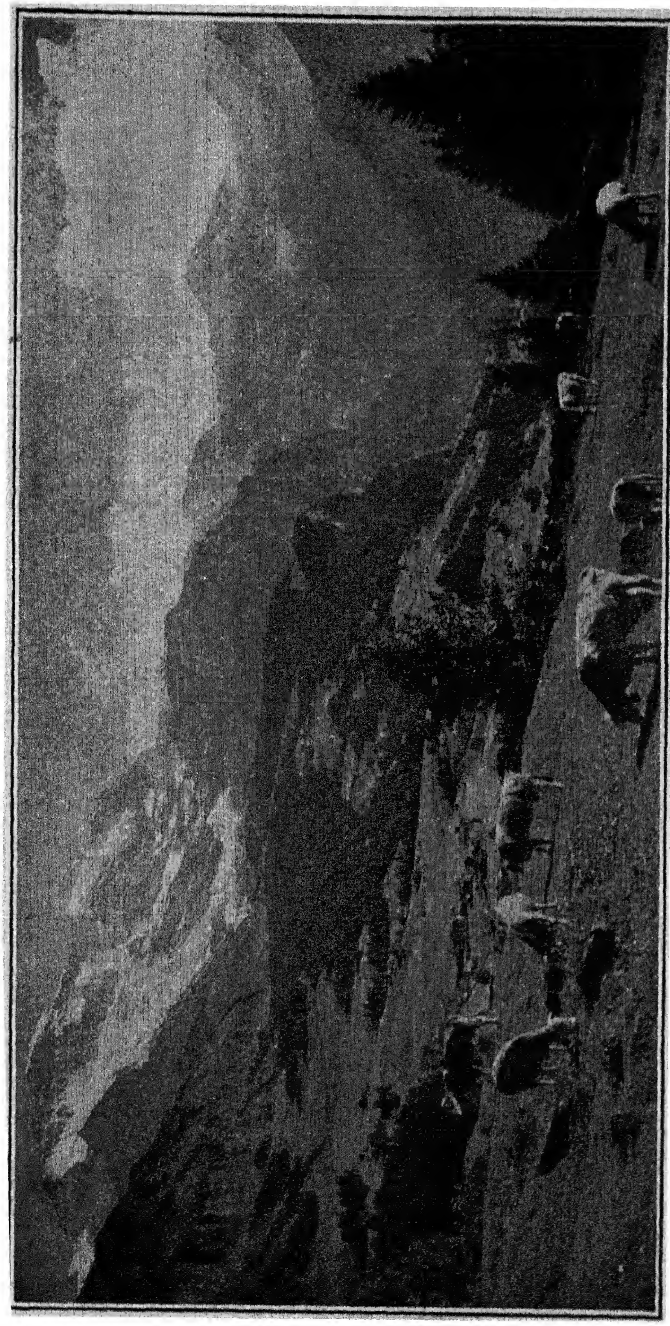
processes of metamorphism chalk and limestones are changed to marble; clays and shales to slate; sandstones to quartzite; and granite to gneiss.

The Chief Rocks in the British Isles

The following is a table showing the chief rocks found in the British Isles. Some indication is given of their nature and the localities in which they may be found. The non-sedimentary rocks and the oldest sedimentary rocks are at the bottom of the table and the newest sedimentary rocks at the top. For convenience, the sedimentary rocks are divided into five groups according to their age.

CLASSIFICATION OF THE PRINCIPAL ROCKS, WITH SPECIAL REFERENCE TO THE BRITISH ISLES.

GROUP	CHIEF TYPES OF ROCK	WHERE FOUND IN THE BRITISH ISLES
Quaternary. The newest or Fourth Age.	Alluvium, Boulder Clay, Peat.	Parts of Somerset; the Fens; around estuaries and in river lowlands; Dungeness.
Tertiary or Third Age.	London Clay.	Lower Thames basin; Hampshire basin.
Secondary or Second Age.	Chalk, Clay, Jurassic or Oolitic Limestone. New Red Sandstone.	The scarplands of England, S.E. of the Tees—Exe line; in the lowlands surrounding the Pennines.
Primary or First Age.	Carboniferous Series (including Coal). Old Red Sandstone. Silurian, Ordovician and Cambrian. (The last three groups contain hard sandstones, limestones, shales and slates.)	The North and West Highlands of the British Isles; viz. Ireland, Cornwall and Devon, Wales, the Pennines and Scotland.
Archaean.	Pre-Cambrian.	N.W. of Scotland; the Longmynd in Shropshire.
Igneous and Metamorphic.	Granite, Basalt, Gneiss, etc.	Highlands of Scotland, Cheviots, Western Mountains of Ireland, Lake District, parts of Wales, Dartmoor and the moors of Cornwall.



W. Gahi, Wengen

THE JUNGFRAU FROM THE NEIGHBOURHOOD OF WENGEN—TO THE RIGHT THE LAUTERBRUNNEN VALLEY.

This is a good example of a view taken in a region of new fold mountains. Notice the rugged outlines of the summits; their varying heights; the snow and glaciers of the highest levels; the coniferous forests on the lower slopes; and the "alp" with its settlement and cattle pastures high above the level of the main valley.

THE MAJOR LAND FORMS OF THE WORLD

A good physical map of the world shows that, broadly speaking, there are three main types of land to be considered. These are:—

(1) Mountains.

(2) Plateaux.

(3) Plains.

Most of the land surface of the earth can be included under one or other of these headings.

Mountains

Mountains are often classified according to their mode of formation, viz. (*a*) Fold mountains; (*b*) Block mountains; (*c*) Residual mountains; (*d*) Volcanic mountains.

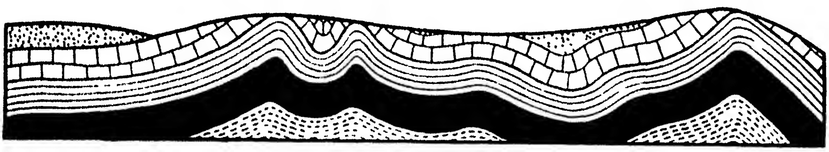


Fig. 48. DIAGRAM TO ILLUSTRATE THE SIMPLE FOLDING OF ROCKS.

(*a*) FOLD MOUNTAINS.—High mountain chains such as the Himalayas, Andes, Alps, and Rockies are known as *new fold mountain* systems. The term "fold" is a reference to the way in which such mountains have been formed. Throughout millions of years slow movements of the earth's crust have caused these mountains to be raised. The movements which have resulted in mountain buildings were not, however, vertical uplifts. They were primarily horizontal movements, the effect of which was to cause the crust of the earth to "wrinkle," in a similar way to which a tablecloth wrinkles if it is pushed along the table. Mountain building is undoubtedly due to some deep-seated cause. For a long period the most simple explanation was that folding was ~~entirely due~~ to the cooling and contraction of the earth, so that the crust, already cold and shrunken, had to wrinkle to fit itself to the still cooling and contracting "core." One of the objections advanced against this theory is that the amount of shrinking

necessary to account for the Himalayas, Alps, etc., seems to be greater than the mere contraction of the earth would allow.

While the theory of contraction cannot be completely rejected, serious consideration must be given to the more recent explanations of mountain building. For instance, Wegener suggests that mountain building may be due to the "wrinkles" produced by the drifting of a continental mass, *e.g.* that the Alps were formed by the northward drift of the African continent towards the more stable blocks of Central Europe. As the African mass drifted slowly northward the zone between it and the European mass became narrower, and the land was raised into high ridges or folds. The raising of the Alps was accompanied by the formation of the deep trough which contains the Mediterranean Sea. The same hypothesis would account for the building of the Himalayas and the depression of the Indo-Gangetic trough by the northward drift of the Deccan mass.

During the physical history of the earth, mountain building appears to have proceeded more actively at some periods than others. Fold mountains are, therefore, not all of the same age. The newest group of fold mountains include the Himalayas, Alps, Rockies, and Andes. During an earlier period of folding (the Carboniferous) the Pennines, Appalachians, the Cape Ranges of S. Africa, and the Dividing Range of Australia were uplifted. A still earlier period of folding accounted for the original mountains of Scotland and Norway, of which the present mountains are merely the worn down stumps. The older fold mountains, which have been subjected to the forces of denudation (such as the weather, rivers, glaciers, etc.) for long geological periods, are much lower and less rugged than the newer fold mountains.

The term "new fold" is applied to the mountain ranges which have been folded most recently, but they seem very old when their age in actual years is considered because they were uplifted many millions of years before historic time. Mountain building is a very long and slow process, and in the case of certain mountain chains, such as the Andes and the mountains of Japan, is probably still proceeding.

The new fold mountain systems of the world, except in such instances as the simple low folds of the Weald (S.E.

England) usually consist of high parallel ranges, the average height being well over 10,000 ft. In the Himalayas the highest peak rises to 29,000 ft.; in the Andes 23,000 ft.; in the Rockies 20,000 ft.; in the Alps to 15,000 ft. Vast though these heights appear the wrinkles of the earth's crust are only slight. The highest mountain in the world (Mt. Everest) is about 5 miles high, so that on a globe of 16 in. diameter it would protrude only ·01 in.

Most of the active volcanoes are found in the neighbourhood of fold mountains where the crust of the earth has been fractured during the process of folding. All around the Pacific Ocean there are many active and extinct volcanoes, as in New Zealand, the East Indies, Japan, and North, Central, and South America. Another belt of active volcanoes is associated with the fold mountains of the West Indies.

The mountains of this type are characterised by ruggedness of relief in contrast to the smooth and rounded contours of mountain areas which have been subjected to weathering agents for long periods of time. This is obvious if pictures of the Alps and the Scottish Highlands are compared.

Mountains are effective climatic barriers, and the climates of regions on either side of a high mountain range are very different. For example, the coast lands of British Columbia have an equable climate and a heavy rainfall, while the lands to the east of the Rockies have an extreme climate and light rainfall. Again, the climate of the mountainous areas differs from that of the adjacent lowlands.

The great mountain systems of the world are mainly important for their minerals, and, in the temperate zone, for their lumber. In the plateau regions of some mountain systems agriculture has been made possible by irrigation, and above the forests in temperate areas there are valuable alpine pastures. The swift streams of mountains are frequently sources of hydro-electric power, especially in countries which have no coal, such as Switzerland and Norway.

In North America, the Western Cordillera provides gold, copper, lead, and silver, especially in the states of Nevada and Montana. The Andes provide tin and copper (Bolivia), gold and platinum (Colombia), and silver (Peru). The Highlands of East Australia are also important for copper and gold.

The lumbering industry is specially important in British Columbia, Washington, and Oregon (soft woods), the Central American mountainous lands (hard woods), the Himalayan slopes (teak and sal), and the Scandinavian mountains (soft woods).

To provide food for the mining communities in inaccessible mountain areas, agriculture has been developed. There are numerous irrigation schemes in operation in most of the mountain states of the U.S.A., *e.g.* at Salt Lake City in Utah. Similarly, the Andean states, *e.g.* Bolivia, grow small quantities of cereals in their plateau areas.

Mountain pastures have been utilised most extensively for cattle rearing in Switzerland and Scandinavia.

The vast central plateau of Asia is, owing to difficulty of access and climatic extremes, so isolated from other regions that very little development of any kind, on modern lines, has taken place.

High mountain ranges are also barriers to communication, and so tend to separate peoples. Traffic across mountains is limited to the passes which are often so high as to be snow-bound in winter. Such ranges as the Alps, Andes, etc., can only be crossed with great difficulty or by expensive tunnelling.

(*b*) BLOCK MOUNTAINS.—It sometimes happens that movement of the earth's crust occurs along cracks or faults. Where such movement leaves a block of higher land standing between two areas of lower land, the highland is known as a " Block Mountain " or *horst*. The Vosges and Black Forest Mountains are examples of such formations (Fig. 49). These mountains are usually very steep-sided, and often the summit levels are roughly the same.

(*c*) RESIDUAL MOUNTAINS.—When an area of highland remains standing above the general level after rivers and other natural agents have lowered the surface of the surrounding area, the name *residual* mountain is used. Sometimes such highlands are called " mountains of denudation." This term can usually be applied to the mountain ridges associated with " dissected plateaux " (see page 80). Included in this class are the mountain ridges of the Highlands of Scotland, the Sierras of Central Spain, and the *Mesas* and *Buttes* of the western plateau lands of the United States.

(*d*) VOLCANOES.—Mountains may be formed by the accumulation of volcanic material piled up round a crater (see page 146).

Plateaux

A *plateau* or tableland generally denotes a large stretch of highland which is practically the same height above sea-level, and which descends on all sides to lower ground. Some plateaux, however, such as those of Tibet and Bolivia, are

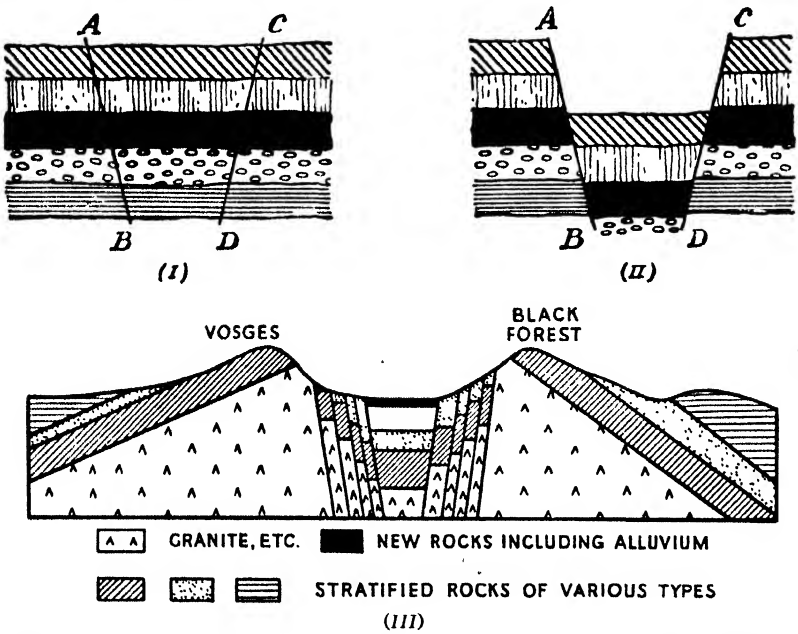
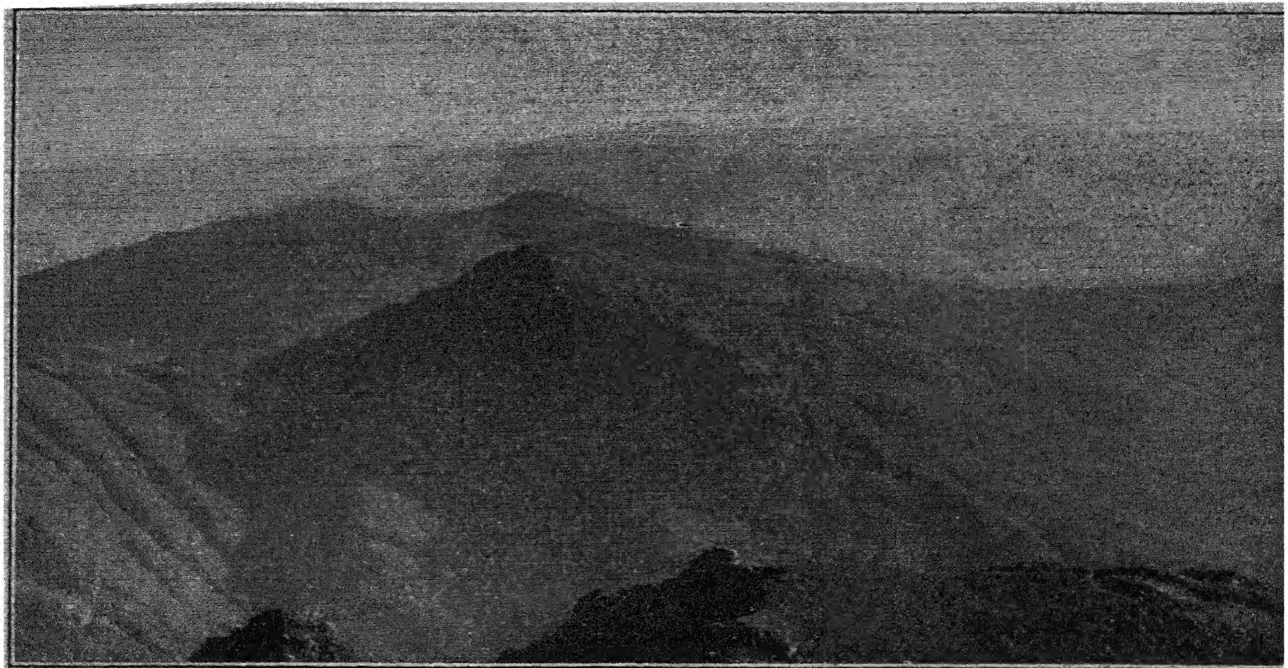


Fig. 49. (I) AND (II). A SIMPLE CONCEPTION OF A RIFT VALLEY. (III) SECTION ACROSS THE RHINE RIFT VALLEY.

fringed by high mountain ranges which tower above the plateau level, and are known as *intermont plateaux*. Sometimes they are so completely enclosed as to have no outlet to the sea. A plateau might be regarded as an elevated plain, but there is often a great difference between the surface of a plain and that of a plateau. As a plateau is high, rivers are swift and carve deep, narrow valleys instead of the broad, open valleys of the slower rivers of the plains. Such plateau areas as Wales, and the Highlands of Scotland are broken by deep, narrow valleys, and are termed *dissected plateaux*.



The "Daily Mail"

BEN ARTHUR AT THE TOP OF LOCH LONG, ARGYLLSHIRE.

The above picture shows a portion of the Northern Highlands of Scotland. The region is a dissected plateau. In the background may be seen a number of mountain ranges whose summits are all approximately of the same height. The ranges are separated by deep glens which have been formed by river erosion.

On reaching the top of such an area one has a long view of a series of flat-topped mountain ridges. These ridges are all of approximately the same height, and if one imagines the clouds descending until they touched one ridge, then almost every other ridge would be similarly cloud-capped. Other good examples of plateaux are Tibet in Asia, the Ecuador and Bolivian plateaux in South America, and nearly the whole of the continent of Africa. The Deccan of India is a plateau that has been tilted so that the western edge is much higher than the eastern edge, and all the main rivers drain eastwards.

If you study Salisbury Plain in your atlas you will see that it is higher than the surrounding country. It is, in reality, a low plateau, and not a plain, but the term "plain" has apparently been applied because of the level nature of its surface.

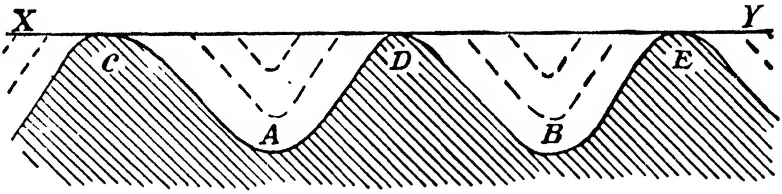


Fig. 50. Shaded area represents land. Dotted lines illustrate the growth of the valleys. This shows how a plateau is "dissected."

In many instances plateaux are formed by the denudation or wearing down of higher mountainous areas. Ultimately such areas may become so low that they are nearly plains, i.e. *peneplains*, such as the land around Hudson Bay.

Millions of years ago lava was forced up through cracks in the earth's crust, and spread out over the land in great sheets which have since hardened to form plateaux of basalt. Two well-known examples of such plateaux are in Antrim (N.E. Ireland), and on the Deccan of India to the east of Bombay.

Many of the most extensive areas of plateaux in the world are composed of very hard old rock. The Guiana Highlands, most of Africa, Arabia, the Deccan of India, and the West Australian plateaux are all composed of rocks, of similar age. These are shown on Fig. 45.

The ancient plateau lands are principally valuable for their minerals, such as the gold of Western Australia; the iron and

manganese of the Brazilian Highlands; the gold, copper, and diamonds of the African plateau; and the gold of the Lena plateau in Siberia.

Where plateaux are found in tropical areas they are important because, being cooler than the neighbouring lowlands, they offer greater possibilities for successful European settlement and development. The highlands of Brazil, Kenya, and Tanganyika are illustrations of this.

Much of the tropical plateau area is covered by savana grasslands. For the most part, these areas are not yet developed, but offer possibilities for the production of a large variety of both animal and vegetable products, when communications have been developed and further settlement has taken place.

Plains

A *plain* is an expanse of low and nearly level land. Some plains, such as the Fens of England, large parts of Holland, and extensive areas of Russia, are almost perfectly flat; but generally an extensive plain consists of wide, gently sloping valleys separated by low hills. Such a plain is termed "rolling" or "undulating." Many plains look extremely flat when viewed from the top of the neighbouring hills, but on descending one finds numerous instances of steep gradients, these being the valley slopes of the streams which cross the plain.

Plains are not all of the same type. Firstly, some may have been formed by the wearing down of lands that were once much higher. Such areas are more correctly called "peneplains." Good examples are Finland, a lowland area of very old rock, and the Hudson Bay lowlands.

Secondly, where layers of rock have not been folded but remain almost horizontal, extensive plains also occur. The Central Plains of the United States and the great plains of European Russia are in this group.

Thirdly, plains may have been formed by the gradual accumulation of silt brought down by rivers. These are usually called *alluvial plains.* Good examples are the plain of North China, the Indo-Gangetic plain, the plains of Iraq, and much of the Amazon lowland. Some plains are the beds of old lakes. Rivers entering a lake deposit silt which is spread by the movement of the water over the lake floor.

Such plains, though not large in size, are usually very fertile. Much of the great wheat lands of Southern Manitoba is the bed of an old lake—Lake Agassiz. The fertile plains of Hungary are of similar origin.

Finally, some plains are formed by the uplift of part of the sea floor bordering a continent. The coastal plains of the United States from Chesapeake Bay to Florida were formed in this way.

The plains of the world tend to be the areas of most advanced development and densest settlement. They are easier to cultivate than highland areas as the soil is usually deeper and more fertile. Hence the great plains, except where covered with large tracts of uncleared forest or occasional deposits of infertile soil, are important agricultural lands. Some plains, such as portions of Central Asia or of the Murray-Darling basin, are too dry for successful agriculture. Unless irrigation is a practical possibility such plains are occupied by pastoral farmers engaged in rearing animals, and even the pastoral farmers sometimes have to bore wells for water, as in Hungary and in Australia. Where coal is found in or near plains, densely populated industrial centres usually develop, as in the North-Central United States. Movement is easy in all directions over lowlands, and rivers are generally slow and easily navigable, so that they are used as commercial highways. This is well illustrated by the United States where the Mississippi and its tributaries provided the main lines of communication before the period when railways were developed.

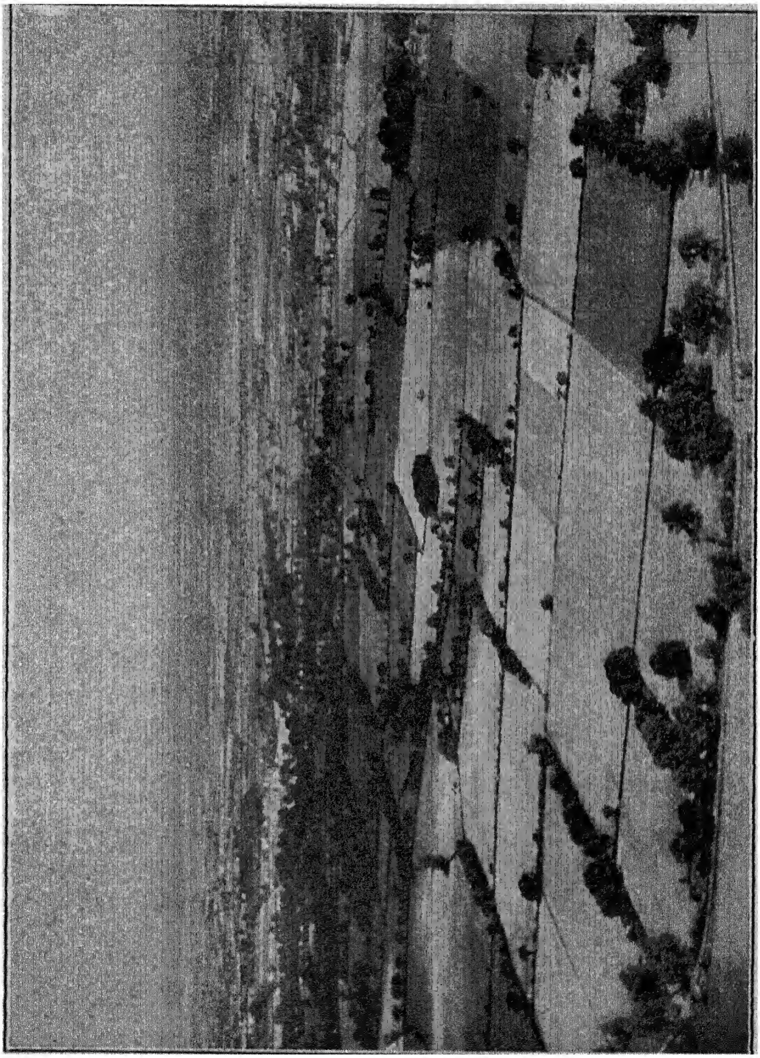
Distribution of Land and Water

Land and water are not uniformly distributed over the earth. There is more than twice as much water (71 per cent.) as land (29 per cent.), but in the Northern Hemisphere the areas of land and water are nearly equal, while in the Southern Hemisphere there is nearly 15 times as much water as land.

A careful study of a globe reveals a number of outstanding points concerning the distribution of land and water.

(1) In nearly every instance if there is land in one part of the globe then there is water opposite to it on the other side of the earth. Even the North Polar *Ocean* is opposite to the Antarctic *land mass*. This can be clearly shown by

drawing an outline map of the world and then drawing another one on transparent paper and placing it upside down over the first map, as has been done in Fig. 51.



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AN AERIAL VIEW OF THE PLAIN OF ESSEX.
This is typical of the agricultural plains of England.

(2) The greatest land-masses form an almost complete girdle around the Northern Hemisphere in the temperate latitudes.

(3) The land masses are narrowest in the southern hemisphere.

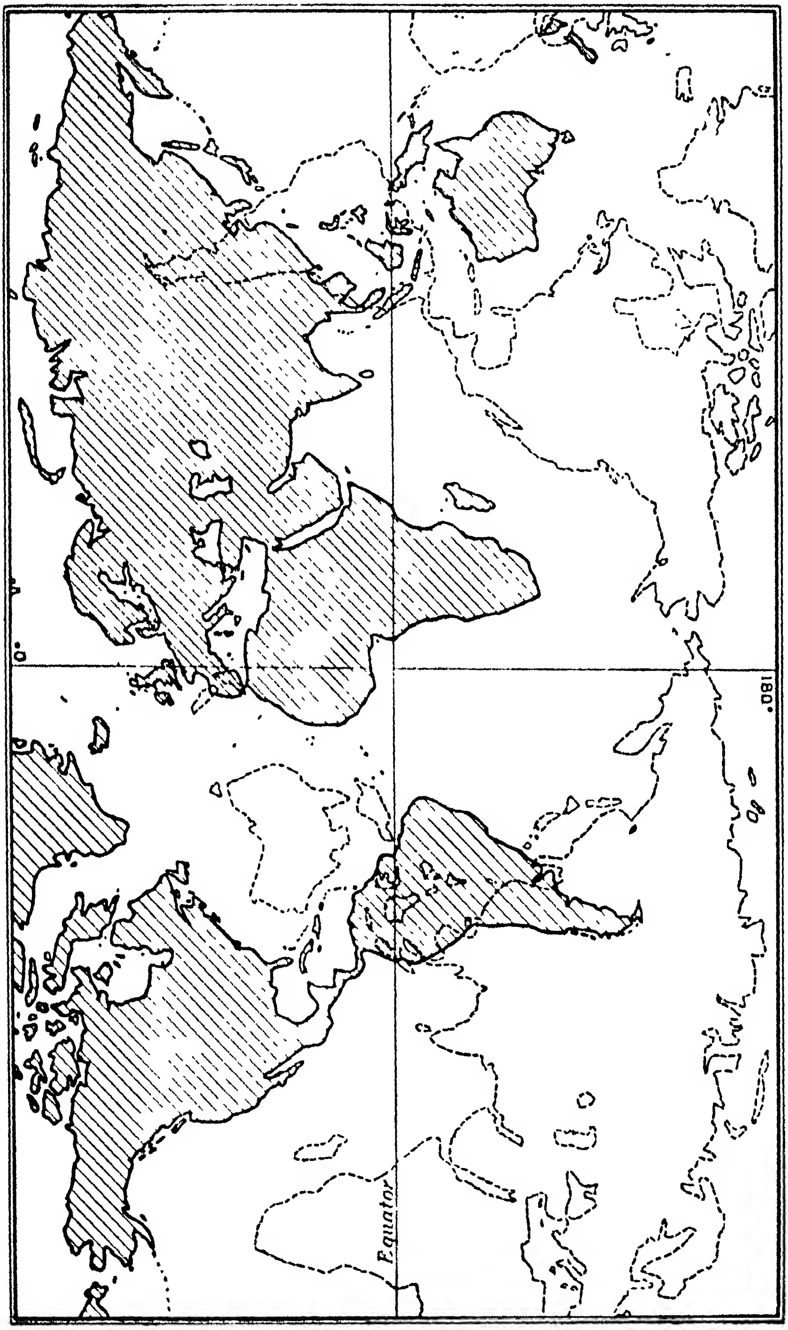


Fig. 51. To Show the Antipodal Distribution of Land and Water.

(4) The Antarctic land mass has three protruding areas, one extending towards South America, a second towards South Africa, and a third towards Australia.

Some scientists have attempted to account for this arrangement of land and water by the "Tetrahedral Theory," but this explanation is not accepted by all. It is based on the assumption that as a sphere collapses or contracts, it tends to become tetrahedral in shape. (A tetrahedron is a pyramid with four triangular faces, *i.e.* a 3-sided pyramid on a triangular base.) If this assumption is correct then the distribution of land and water is explained by the diagram (Fig. 52), the continents corresponding to the edges of the tetrahedron and the oceans to the faces.

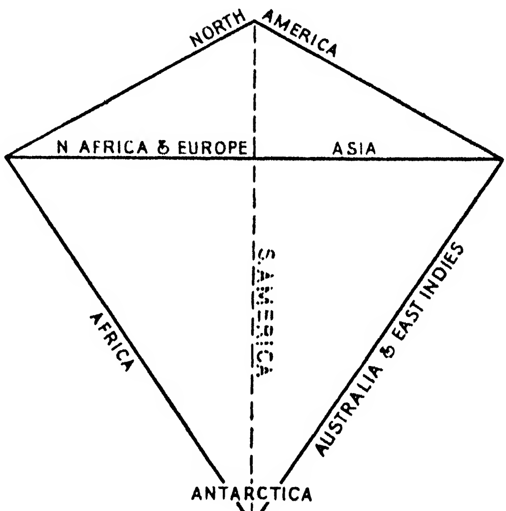


Fig. 52. Diagram to Illustrate the Tetrahedral Theory of the Distribution of Land and Water.

The following important facts may be said to arise from this distribution of land and water:—

(1) The development of a Northern Hemisphere "girdle" of communications: viz. North Atlantic sea route, North American transcontinental railways, North Pacific sea routes, and the Trans-Siberian railway.

(2) East to west routes are important in the northern hemisphere, in contrast to the importance of north to south routes in the southern hemisphere. There is no important east-west route linking South America, South Africa, and Australia.

(3) The southern continents, especially Australia, are more isolated than the northern land masses.

(4) The development of world airways is easier in the northern hemisphere than in the southern hemisphere.

(5) The interior of continents of the northern hemisphere have great variations in summer and winter temperatures, while the climates of the southern hemisphere are more equable.

(6) Because the southern continents do not extend beyond 55° S., there is a complete " circle " of ocean between the southern continents and Antarctica.

(7) The southern land masses are relatively narrow in temperate latitudes, so that there is less land in the southern hemisphere suitable for white settlement than in the northern hemisphere.

CHAPTER IV

THE OCEANS

The Ocean Floor

The sea fills all the hollows of the earth's surface which lie below " sea-level " with the exception of a few landlocked depressions, such as the land surrounding the Caspian Sea, the polders of Holland, and the valley of the River Jordan. Whereas the average height of the land above sea-level is 2750 ft., the average depth of the oceans is 12,300 ft. The greatest depth of the ocean at present known is 35,400 ft. (the Mindanao Deep off the east coast of the Philippine Islands). On a globe of 16 in. diameter this deep abyss would only be shown by a scratch $\frac{1}{100}$ in. deep, showing that the mountain heights and ocean deeps make very little difference to the spherical shape of the earth, in fact no more than the irregularities on the skin of an orange.

The ocean floor is often referred to as being composed of four parts:—

(*a*) *The continental shelf*, a shallow area surrounding the land masses and never more than 600 ft. (100 fathoms) deep. The boundary of the Continental Shelf is known as the Continental Edge.

(*b*) *The continental slopes*, the steep slopes descending from the continental edge to the deep sea plains.

(*c*) *The deep sea plains*, a monotonous undulating area usually more than 2 miles below sea-level, and comprising the greater portion of the ocean floor. In some places the oceanic plain plunges to great depths known as the ocean deeps.

(*d*) *The ocean deeps*, which are usually long, narrow, trough-like depressions.

These four divisions are shown on the section of the Atlantic Ocean (Fig. 53).

The Atlantic Ocean

In shape, the Atlantic Ocean is somewhat like a letter S. The coastlines of the Americas, and Europe-Africa being

approximately parallel. In the North, where extensive plains reach down to the sea, there are wide areas of Continental Shelf on both the eastern and western sides; viz. (*a*) around the British Isles; (*b*) around Newfoundland and North-Eastern U.S.A. In contrast, the Continental Shelf in the South Atlantic is much narrower, especially where the plateaux of Africa and Brazil drop steeply to the coast.

Running southwards in the middle of the Atlantic, halfway between the two continental masses and roughly parallel to their coasts is a submarine ridge. This ridge, known as the Dolphin ridge in the North Atlantic and the Challenger ridge in the South Atlantic, occasionally rises above sea-level. Where this occurs are islands such as the Azores, St. Paul's Rocks, Ascension, and Tristan da Cunha. Such islands as these are known as *oceanic islands* because they rise from the

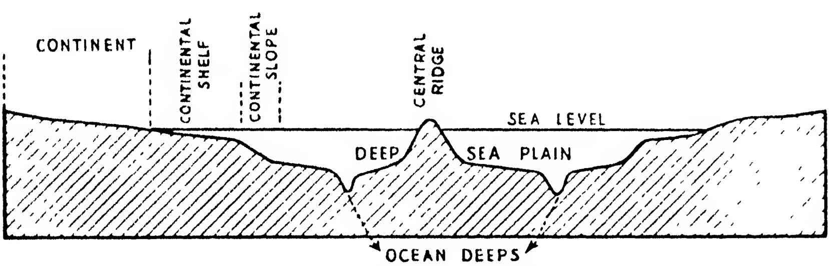


Fig. 53. Diagrammatic Section of the Atlantic Ocean.

depths of the ocean; in contrast, islands like Newfoundland and the British Isles which only rise from the shallow floor of the continental shelf are known as *continental islands*.

On each side of the Central Atlantic ridge are the great deeps, but the deepest Atlantic sounding yet taken is that of the Nares Deep (27,972 ft.) just north of Porto Rico.

The Pacific Ocean

In contrast to the Atlantic Ocean, the Pacific Basin is almost everywhere surrounded by high mountain chains (viz. Andes) or volcanic islands (Japan). The results of this are twofold:—

(1) There is relatively little continental shelf.

(2) The sea floor drops very steeply from the continental margins so that the great ocean deeps are very near to the

eastern and western margins of the ocean; viz. the Tuscarora deep (off East Japan), the Mindanao deep (off the Philippines), and the Russell deep near to the coasts of Chile (Fig. 54).

A well-marked line of deeps extends from Japan southwards, keeping just to the east of the Ladrone, Marshall, Tonga, and Kermadec Islands. These islands seem to form the outer edge of a platform, 2000-4000 ft. deep, which extends eastwards from Asia and Australia. A similar platform stretches westwards from South and Central America. Between these two platforms the ocean bed sinks to the deep sea plain. From the Pacific submarine platforms rise plateau-like areas which are topped by volcanic and coral islands (see page 158), *e.g.* Hawaii.

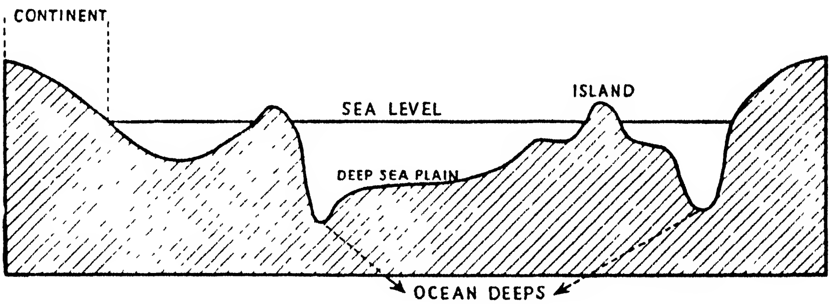


Fig. 54. Diagrammatic Section of the Pacific Ocean.

The Covering of the Ocean Floor

The floor of the ocean is covered with muds, oozes, and clays. The muds and clays are derived from the land and are often termed *Terrigenous* (land derived) deposits, but the oozes are formed by the deposition of the skeletons of minute sea organisms, and are termed *Pelagic* (ocean derived) deposits.

(1) Muds.—These include all gravels, sands and silt carried out to sea by rivers, and material broken by waves from the sea coasts. It is usually dull blue in colour (blue mud), and extends over all areas of shallow water surrounding the land masses. Where there are very strong river currents (*e.g.* the mouth of the Amazon) blue mud may be found 400-500 miles from land, but its usual limit is 200-300 miles out to sea. On the " continental slopes " these muds are finer in texture and are often green or red, varying in colour according to their chemical constituents.

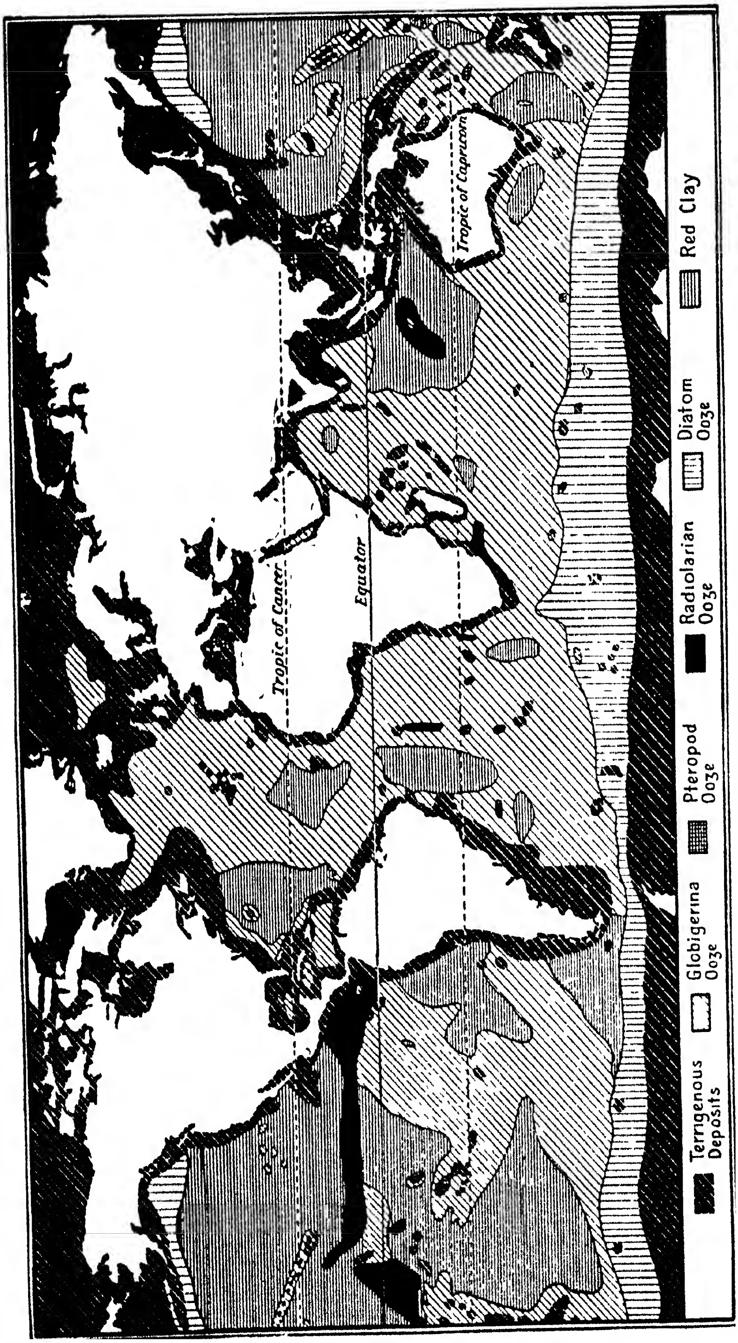


Fig. 55. OCEANIC DEPOSITS.
(Based on the *Oxford Advanced Atlas* by *Bartholomew*)

(2) Oozes.—Living in the ocean waters are countless millions of microscopic organisms. For the most part these are in suspension. As these organisms die they descend to the ocean floor and one may imagine a constant " rain " of them on the bottom of the ocean, resulting after very long periods of time in the formation of deposits composed of the tests or skeletons of these organisms. It will be realised that these deposits grow extremely slowly. These accumulations are known as oozes, and are found on the ocean floor far away from the continents. The general colour is light grey, and when dry an ooze is rather like flour in texture. There are four principal types of ooze:—

(*a*) Globergerina } composed of Calcium Carbonate.
(*b*) Pteropod }

(*c*) Diatom } composed of Silica.
(*d*) Radiolarian }

Globergerina ooze is very widespread. It covers most of the floor of the Atlantic Ocean and much of the Indian and South Pacific Oceans.

Pteropods only live in warm oceans, and as they dissolve before they reach the deep sea plains, pteropod ooze only occurs in shallower waters (less than 1000 ft. deep). Thus this ooze is found in patches on the Atlantic ridge and on the submarine elevations of the Pacific and usually within the tropics.

Diatoms flourish in the cooler oceans, and diatom ooze is found in a wide belt encircling Antarctica.

Radiolarians, in contrast to Diatoms, and like Pteropods, live in the warmer seas. As the siliceous skeletons do not dissolve easily, Radiolarian ooze is found at great depths, in the inter-tropical areas of the Indian and Central Pacific Oceans.

It is obvious that the remains of sea organisms will also accumulate on the sea floor near to the continents. Here, however, it will be mixed with such a large amount of land derived material that the percentage of "ooze" is negligible.

(3) Red Clay.—This is a stiff brownish-red clay found over very large areas in the Pacific Ocean, and in the great deeps

of the Atlantic and Indian Oceans. The chalky and siliceous remains of sea organisms completely dissolve before they reach these great depths, hence oozes are absent. Red clay is thought to be the accumulation of dust particles which have been blown out to sea after volcanic eruptions, and which, being insoluble, have gradually sunk to the ocean floor. Red clay therefore accumulates very slowly. Such particles would also reach the sea floor in the shallow areas, but there the other oozes predominate.

The Salinity of the Ocean

The average salinity of the ocean is 3·5 lb. of salt to 100 lb. of water, or 35 lb. to 1000 lb. of water (written $35^{\circ}/_{oo}$). These salts include sodium chloride (common salt) of which there is 27 lb. to 1000 lb. of sea water, and also compounds of magnesium, potassium and calcium. The rain water flowing over the land surface or sinking into the soil and into the crevices and pores of the rock, perhaps eventually reappearing as a spring, carries away certain minerals in solution. All river-water contains dissolved minerals which are eventually carried to the sea. It might reasonably be thought that the composition of sea-water should be similar to that of river-water, but this is not so. Calcium carbonate is not, however, the principal salt contained in sea-water, because sea organisms are constantly absorbing it to build their shells and skeletons.

The salinity of sea-water is not uniform, and it depends mainly on two factors, viz.—

(1) The amount of fresh-water added by rivers and rainfall.

(2) The rate of evaporation.

Excluding certain partially enclosed seas which will be discussed later, the salinity of the oceans varies in marked east to west-trending belts. Since warm water will dissolve more of a given substance than cold water it would be expected that the areas of greatest salinity would be found near the equator. This is not so.

(*a*) In the equatorial areas, the rainfall is heavy and occurs almost daily, and the relative humidity of the atmosphere is high so that there is little evaporation. In addition there are rivers of large volume (*e.g.* Congo and Amazon) which

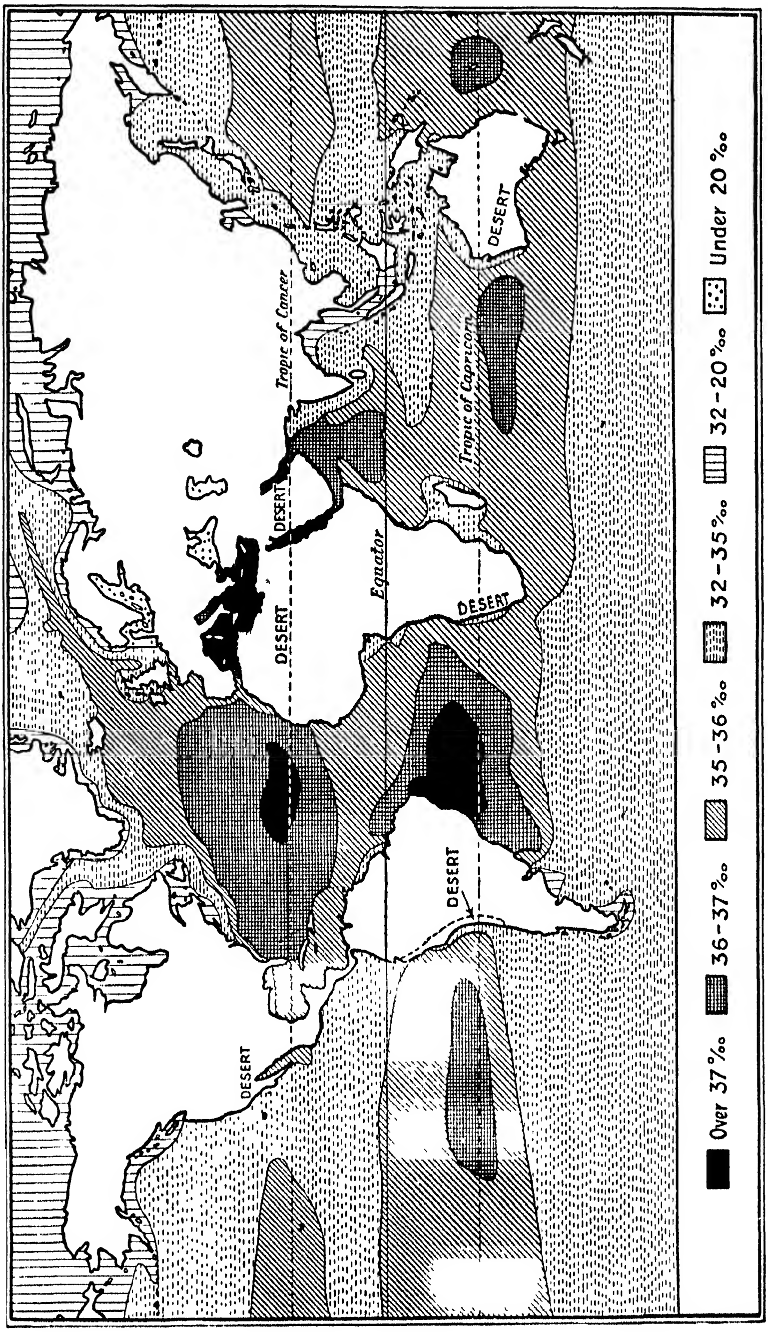


Fig. 56. SALINITY OF THE SURFACE WATER OF THE OCEANS.—Notice that the hot deserts and the areas of greatest salinity lie in the same latitudes.

constantly supply fresh water. As a result the salinity is not high but below normal, *i.e.* below 35°/₀₀. The approach by sea to the mouth of the Amazon is sometimes determined by the presence of relatively fresh water.

(*b*) North and south of the equatorial area are the Trade Wind belts. It will be shown later (page 190) that Trade Winds are drying winds. Therefore evaporation is rapid in these latitudes (about 20° to 30° N. and S. of the equator). On the land in these latitudes are the great deserts, so that there are relatively few rivers to add a supply of fresh water. In these belts the salinity rises to $37°/_{oo}$ and over. The map (Fig. 56) shows that the great deserts and the areas of high salinity form two parallel belts around the earth.

Where really large rivers enter the sea in these belts the salinity is lowered, viz. at the mouths of the Zambesi, the Ganges, the Mississippi, and the rivers of Indo-China.

(*c*) Proceeding polewards from the Trade Wind belt, the salinity gradually decreases until, in the poleward sections of the Arctic Ocean it is only from $20°/_{oo}$ to $30°/_{oo}$. Here there is less rapid evaporation, more rain, more rivers, and a large supply of fresh water from melting ice.

The Salinity of Partially Enclosed Seas

The Mediterranean Sea has a very high salinity ($40°/_{oo}$). It is partially enclosed, and its waters do not circulate freely with those of the open ocean. It is in a region of rapid evaporation, particularly during the summer, when, too, many of the rivers become almost dry. The one really large river, the Nile, adds less and less fresh water year by year because of the increasing demands for irrigation purposes. For similar reasons very high salinities are found in the Red Sea and Persian Gulf.

The Baltic Sea contrasts strongly with the Mediterranean. It, too, is nearly enclosed, but it is in a cooler region with a lower rate of evaporation. Some large rivers (Oder, Vistula) empty into the Baltic, and numerous streams flow from the snow clad mountains of Scandinavia, bringing a constant supply of fresh water. As a result the salinity is only $2°/_{oo}$, and the water is nearly fresh. One of the important results of this low salinity is that the Baltic Sea freezes readily.

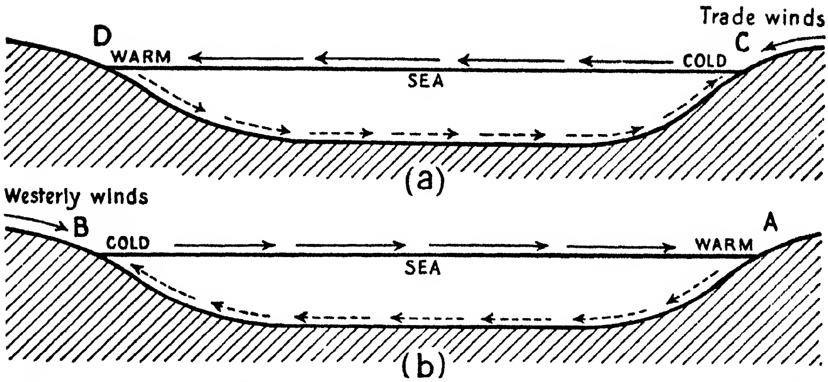


FIG. 57. (*a*) TO SHOW THE EFFECT OF WINDS ON OCEAN TEMPERATURES IN LATITUDE 30° N. (*b*) TO SHOW THE EFFECT OF WINDS ON OCEAN TEMPERATURES IN LATITUDE 50° N.

The Black Sea and the Caspian Sea, each fed by rivers of large volume from the Russian plains also have low salinities. In contrast, the Dead Sea, which like the Caspian is also a region of inland drainage, has a salinity of nearly 240°/₀₀. This is due to several factors, viz.:—

(*a*) Temperatures in the Dead Sea region are high.

(*b*) The rainfall and atmospheric humidity is low.

(*c*) The lake receives water from only a small drainage area.

(*d*) The rate of evaporation is high.

Temperature of the Ocean

In general, the temperature of ocean water decreases from the equator, where the surface temperature is over 80° F. to the polar regions where the water is icy cold.

The decrease in temperature polewards is not regular because of the occurrence of warm and cold currents. For instance in the North Atlantic (about lat. 30° N.) the water on the western side, where there is a warm current (the Gulf Stream), will be warmer than on the eastern side, where there is a cold current [Fig. 57(*a*)]. Further north in the latitudes of the British Isles the conditions are reversed because there is a cold current (the Labrador current) in the west, and a warm drift (the North Atlantic Drift) on the east [Fig. 57(*b*)]. These differences in temperature between the east and west sides of

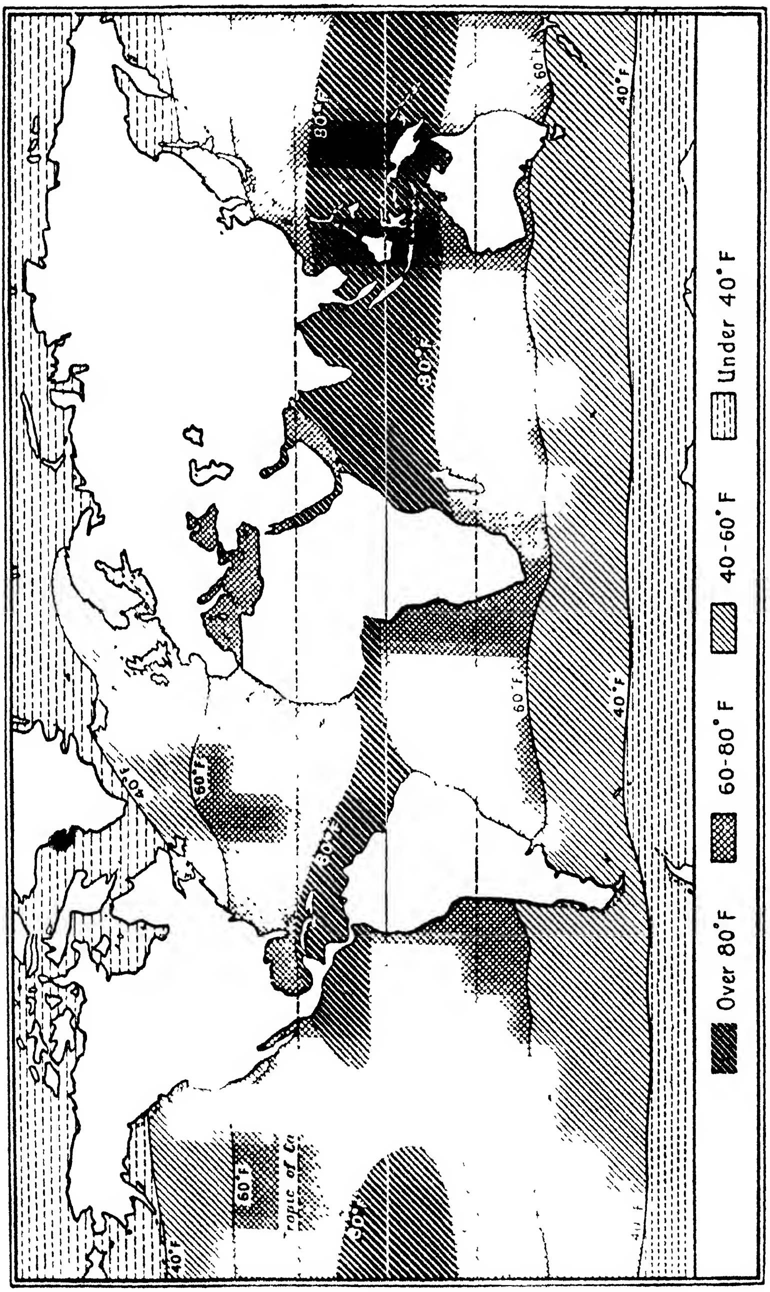


Fig. 58. THE SURFACE TEMPERATURES OF THE OCEAN.
(Based on the Oxford Advanced Atlas by Bartholomew.)

the ocean are partly due to the influence of winds (Fig. 57) and partly to ocean currents (see page 100).

The temperature also decreases with increasing depth. In the upper layers of water the temperature decreases rapidly downwards, then more and more slowly as the water becomes deeper. For example, the temperature may decrease 10° F. per 100 fathoms in the upper layers of water, but at a depth of 1000 fathoms the temperature decreases at less than 1° F. per 100 fathoms. The waters of the ocean deeps (below 2000 fathoms) are uniformly cold, *i.e.* slightly above 32° F.

Submarine ridges, by preventing the free circulation of ocean waters, cause variations in the distribution of temperature. The lower waters of the Mediterranean Sea are 20° F. warmer than the water of the Atlantic Ocean at a similar depth (14,000 ft.). This is because the "sill" between North Africa and Gibraltar prevents the penetration of the cold Atlantic waters into the Mediterranean (Fig. 59).

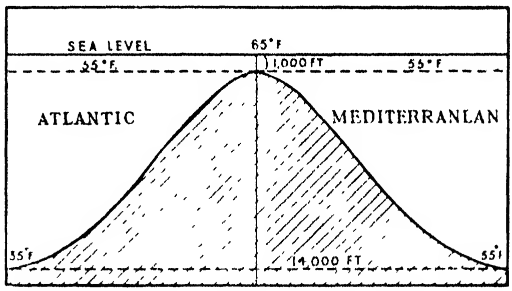


Fig. 59. To Show the Effect of the Submarine "Sill" at the Straits of Gibraltar on the Temperature of the Mediterranean Sea.

The Wyville Thomson ridge which connects Greenland with North Scotland and forms a submarine barrier between the Arctic and Atlantic Oceans has a similar effect. On the Arctic side the water below the level of the top of the ridge is 15° F. colder than water at the same depth in the Atlantic Ocean.

The Red Sea is separated from the Indian Ocean by a bar or sill, the top of which is about 200 fathoms below sea-level. At this depth the temperature of the waters of the Indian Ocean is 70° F. The bar prevents water colder than 70° F. entering the Red Sea. As a result the waters are abnormally warm, and even at a depth of 1000 fathoms the temperature is 70° F. There are many similar examples, the temperature of enclosed seas always being approximately the same as the temperature of the water at the level of the "sill."

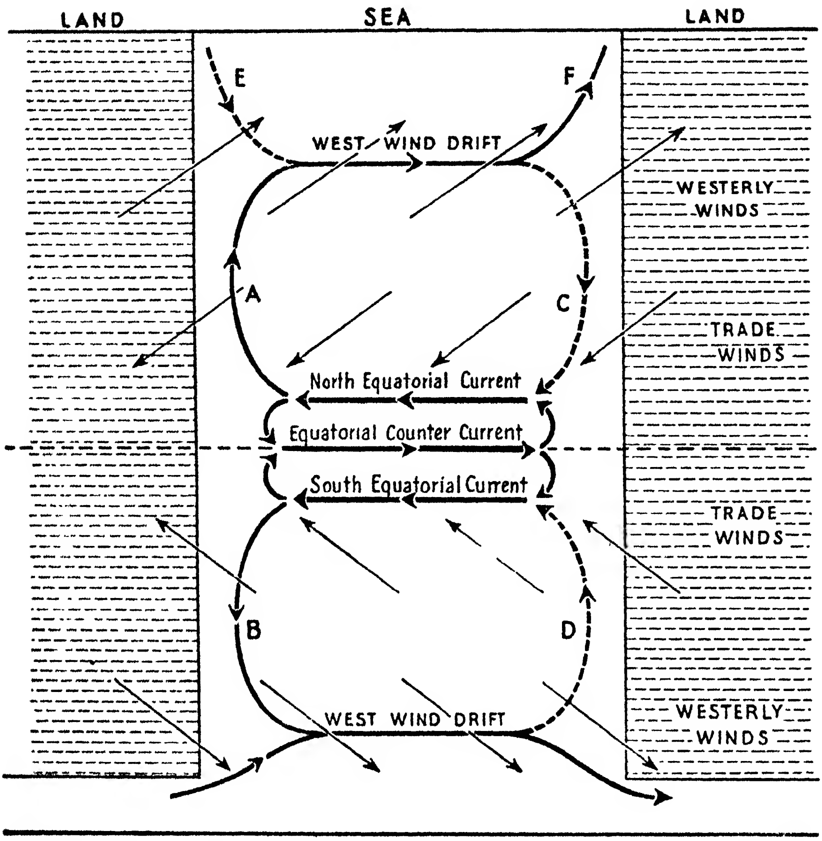


Fig. 60. A Diagrammatic Arrangement of Ocean Currents.

The Movements of Ocean Waters—Currents and Tides

Ocean Currents.—The regular movements of water from one part of the ocean to another are called " Ocean Currents."

Ocean currents are due to a number of much-debated causes, viz.:—

(*a*) Convection and temperature differences.

(*b*) Winds.

(*c*) The shape of the land masses.

(*d*) The rotation of the earth.

It is impossible to separate these factors as they are very much inter-related, but a careful study of Fig. 60 in conjunction with the following explanation will show how and when any one of these factors operate.

Because the water at the equator is warmer and less dense than that in the polar areas, convection currents are set up in the oceans, resulting in a poleward flow of warm, light, surface water and a compensating creep of heavy, cold water through the ocean depths towards the equator. This convective effect is similar to that which produces currents of air (winds) in the atmosphere (see page 182). Just as the winds are deflected by the rotation of the earth so are the ocean currents.

In equatorial latitudes the Trade Winds, blowing with great regularity, drive a wide belt of warm surface water westwards. Between the two there is the eastward-flowing Counter Current. Thus there are in the Atlantic, Pacific, and Indian Oceans a North Equatorial Current, a South Equatorial Current, and an Equatorial Counter Current. On reaching the western shore of the ocean the bulk of the warm equatorial water is deflected north and south by the land masses, and this results in the formation of the currents marked A and B.

About latitude 40° N., current A is joined by a south-flowing cold current E, and the temperature of the warm current is thus lowered and the waters are neither abnormally hot nor abnormally cold. The westerly winds drive this water (which is neither warmer nor colder than the surrounding water) north-eastwards across the ocean. It, in turn, reaches a land mass and is deflected (*a*) partly north as current F, and (*b*) partly south as current C. The latter current rejoins the North Equatorial Current so as to produce a clockwise circulation of water in that part of the ocean lying north of the equator. As current F is carrying waters of the warm temperate zone into colder areas, it is relatively warm compared with the surrounding water. Conversely, current C carries water from the middle latitudes into regions of warmer water, and is relatively cold compared with the surrounding sea. It is referred to as cold current although the temperature of its water may actually be higher than the temperature of the warm current. The important fact is that the waters of current C and F are different in temperature from those of the waters of the surrounding ocean.

In the centre of the " swirls " of the ocean currents are areas of stagnant water where sea-weed accumulates. These areas are often referred to as " Sargasso Seas," though the use of this name should be restricted to the North Atlantic area.

South of the equator a similar set of currents may be found, B being a warm current (cf. A), and D a cold current (cf. C). The general movement of the waters is counter-clockwise, contrary to the direction in the northern hemisphere.

The land masses do not extend so far from the equator in the southern hemisphere as they do in the northern so that cold polar currents have little effect, and a strong West Wind Drift flows, uninterrupted by land, from west to east in the Southern Ocean. There are no currents in the southern hemisphere corresponding to currents E and F of the northern hemisphere.

The details of the circulation of water in each ocean may be understood by applying the facts of Fig. 60 to each ocean in turn, modifying the paths of the currents to the coastlines, and giving the correct names to the currents denoted by letters in the diagram, *e.g.* current D is the cold Humboldt or Peruvian current in the South Pacific Ocean; the cold Benguela current in the South Atlantic Ocean; and the cold Westralian current in the South Indian Ocean.

The currents of the Indian Ocean differ slightly from those of the Pacific and Atlantic Oceans. South of the equator the counter-clockwise movement of the waters is the same in the Indian Ocean as in the South Pacific or the South Atlantic. North of the equator, however, between the equator and southern Asia, the currents are determined by the Monsoons (see page 184). In the summer, when the S.W. Monsoon is blowing, the currents north of the equator flow in a clockwise direction. In the winter, when the N.E. Monsoon is blowing, the currents north of the equator are reversed and flow in a counter-clockwise direction. This causes a disappearance of the N. Equatorial Current in winter, the main flow of water being carried eastward in the Equatorial Counter Current.

The effect of winds on the temperature of ocean currents is shown in Fig. 57.

The climatic effects of Ocean Currents are discussed on page 164.

TIDES.—During a month's holiday at the seaside it can be observed that the level of the sea varies from day to day and week to week. Twice a day the level of the sea rises and

the tide "comes in," and twice a day the level of the sea falls and the tide "goes out." But the rise and fall of the sea is not always the same, and on the days when it rises to its greatest level it also falls to its lowest level. Suppose that on the first day of your holiday the tide rises to level A (Fig. 61) and falls to level D, then each day following, the tide will not advance quite so far as A, nor recede quite as far as D, *i.e.* the difference between high and low water will gradually decrease. At the end of a week it will "come in" or rise to B and fall to C. During the next seven days the height of the high tide will begin to increase and low tide to decrease until it coincides approximately with the levels of A and D. Then once more the tides work back to the levels B and C,

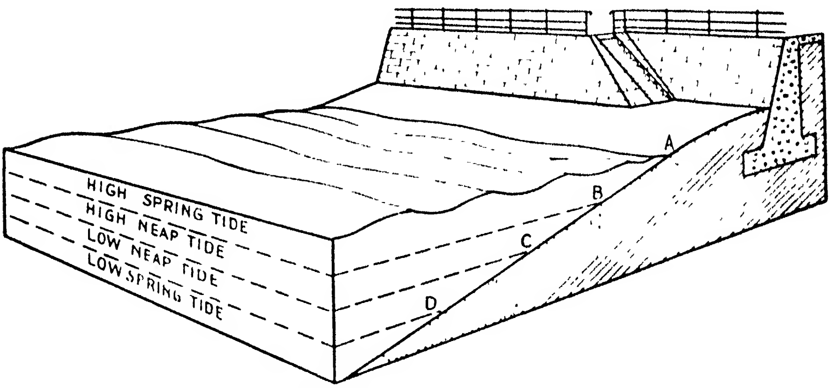


Fig. 61. To Show the Relative Levels of Spring and Neap Tides.

and so on. Thus it will be seen that approximately every fortnight the tides rise to a very high level and fall to a very low level. These tides are known as *Spring Tides.* In the intervening weeks the tides do not rise so high or fall so low. These tides are known as *Neap Tides.* Spring tides and neap tides occur every alternate week. It is important to note that tides are caused by the rising and falling of the sea (*i.e.* a vertical movement) and not by the water flowing inshore and receding (viz. a horizontal movement).

The difference in level between high and low water is known as the *amplitude* of the tide. In the open ocean the difference between high and low water is only 2 to 3 feet so that oceanic islands such as the Azores, Mauritius, Hawaii, etc., only experience a very small rise and fall of the tide.

Because of the narrowness of the Straits of Gibraltar little of the tidal wave can enter the Mediterranean Sea, and so it is practically devoid of tides. Julius Caesar, accustomed to Mediterranean conditions, made special reference to the tides of the English Channel in his *Invasion of Britain.*

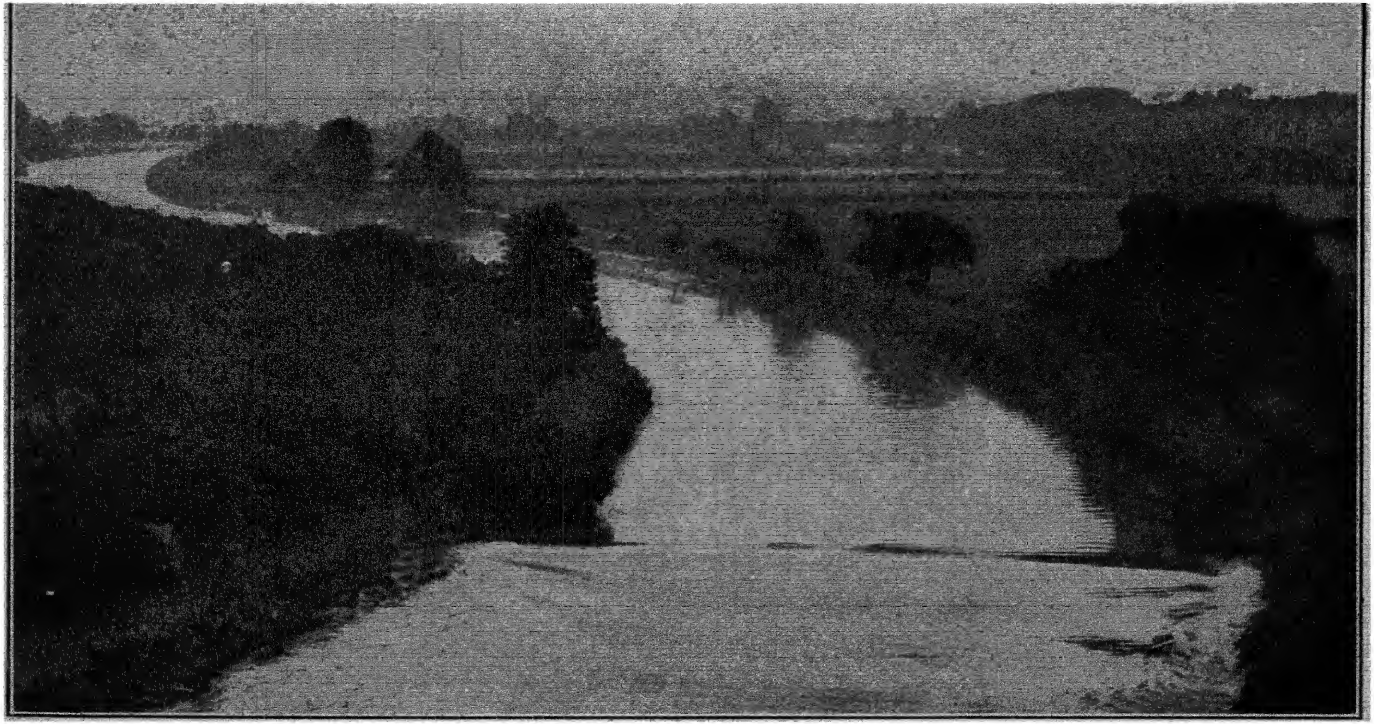
Our islands lie on the Continental Shelf where the sea is comparatively shallow. Because of this shallowness the lower part of the tidal wave is retarded, and there is a " piling up " of water resulting in very high tides. Tidal effects are rendered more spectacular by shelving shores. The estuaries of British rivers would be mere creeks were it not for the tides. The length of our estuaries accounts for the inland position of many British ports. Teddington (Middlesex) is literally the " Tide end town." In gulfs and very shallow estuaries this " piling up " is further accentuated.

The average amplitude of the tide around the British Isles is 10 to 20 ft., but in the Bristol Channel it is as much as 40 ft., and in the Bay of Fundy (Nova Scotia) 70 ft.

As the tides of the shallow seas rise and fall, strong *tidal currents* are set up. These currents help to carry away the accumulation of silt from the estuaries of rivers, and are of great importance to fishermen, who sail out to sea and return to harbour " with the tide." In some estuaries where the tidal wave meets a river of great volume and velocity a special phenomenon results, the tide advancing upstream as an almost vertical wall of water. This is known as the *bore* in the case of the River Severn, the *aegre* (or *eager*) in the Trent, and *le mascaret* in the Seine. The Ganges, Yang-tse-Kiang, and Amazon also have " bores."

The Severn bore does not occur daily, but only when there is a high spring tide backed by a strong south-west wind. It is a source of danger to small boats, but not to large vessels.

Tides are especially important in relation to shipping, for vessels can only enter or leave a dock at high water, *e.g.* ships have to wait off the bar at Liverpool until high water before they can enter the river. Southampton is fortunate in having a very long period of high water, during which ships can enter or leave the port. The reason for this is that one branch of the high tide reaches Southampton via the Solent, and before it has receded another branch reaches the port via Spithead. Thus Southampton has four high tides per day



Associated Press Photo

THE SEVERN BORE.

This picture shows the bore sweeping up the Severn between Stonebench and Minsterworth on September 3rd, 1936, when it reached 10ft. above the normal level of the river.

instead of two, each pair of high tides being about two hours apart.

In some parts of the world the configuration of the land causes the tides to overlap so that there is only one daily tide instead of two. This happens in parts of the Gulf of Mexico.

Off the mouth of the River Rhine the *high tide* from the North Sea meets the *low tide* from the English Channel; six hours later the *low tide* from the North Sea meets the *high tide* from the English Channel. Here then the two branches of the tide constantly neutralise one another. The result of this is that there are no strong currents to carry away the accumulations of silt, and the Rhine therefore has a delta, a most unusual occurrence where a river flows into the shallow waters of the continental shelf. In contrast the rivers flowing into the Mediterranean, where there are no strong tidal currents, all have deltas (viz. Ebro, Rhone, Po, Nile).

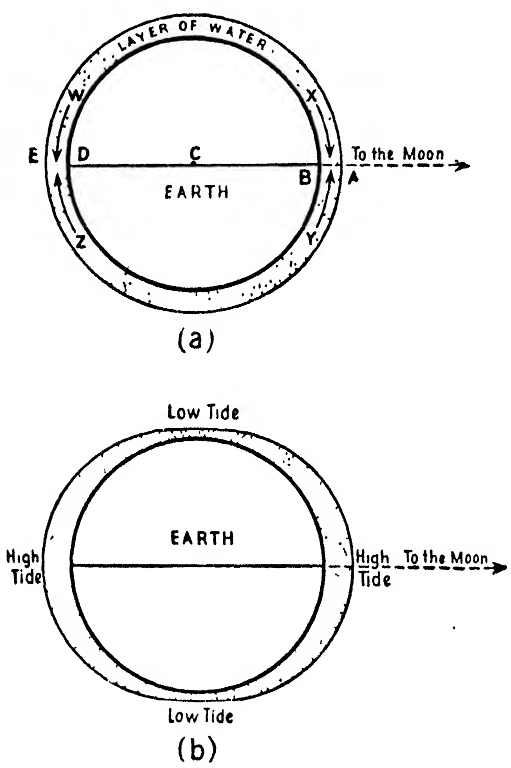


Fig. 62. To Show why there is a High Tide on Opposite Sides of the Earth at the Same Time.

Where a tidal current is restricted to a narrow channel as between groups of islands, it becomes very rapid and is often known as a "race," *e.g.* Pentland Race between North Scotland and the Orkney Islands. Other examples are the Alderney Race, and the Maelstrom among the Lofoten

Islands off the west coast of Norway, and the strong tidal current of the Menai Strait.

Causes of Tides.—It has long been recognised that there is a connexion between the occurrence of tides and the various phases of the moon, for spring tides occur at " new moon " or at " full moon," while neap tides occur at the 1st and 3rd quarters of the moon.

Heavenly bodies attract or " pull " one another. The sun, because of its immense size, should exert a greater " pull " on

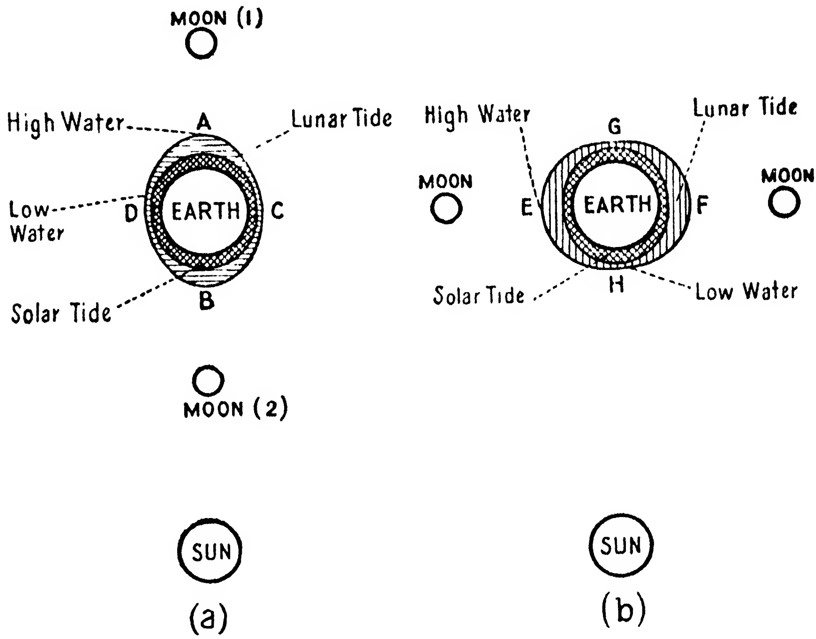


Fig. 63. (*a*) Spring Tides.—Moon (1) is the position of the Moon relative to the Sun and Earth at " Full Moon," and Moon (2) is its position at " New Moon." (*b*) Neap Tides at the First and Third Quarters of the Moon.

the earth than the moon does, but distance as well as size has to be taken into consideration, and because the moon is so much nearer to the earth it exerts a greater " pull " than the sun, even though it is so much smaller. Examine Fig. 62.

The moon is exerting a " pull " on A. Because A is nearer to the moon than B is, the pull at A is greater than the pull at B. Hence the water, being fluid and responding quickly to the " pull," moves along the direction of the arrows X and

Y and " piles up " at A. The pull on B is greater than that on D, and the pull on D is greater than that on E. The water at E is, as it were, being " left behind," and so there is another " piling up " of water along the lines of the arrows W and Z. The result is shown in Fig. 62(*b*). The moon's pull produces two high tides on opposite sides of the earth and between the crests of the high tides is a trough of water known as the low tide. The sun, however, in spite of the great distance between it and the earth, produces tides in the same way that the moon does, but the solar tides are very much smaller than the lunar tides. When the sun, moon, and earth are nearly in the same straight line [Fig. 63(*a*)], viz. at new moon and full moon, spring tides occur. The solar and lunar tides are then coincident (*i.e.* they amplify one another), so that there are very high tides at A and B, and very low tides at C and D.

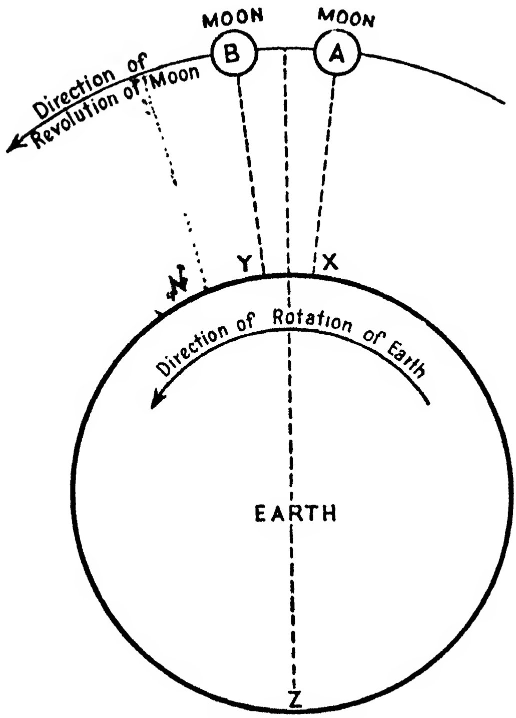


Fig. 64. To Show Why the Time Interval of Consecutive Tides is 12 Hours 26 Minutes.

When the pull of the moon is at right angles to the pull of the sun [viz. at the 1st and 3rd quarters of the moon, Fig. 63(*b*)], neap tides occur. The solar and lunar tides then partly neutralise one another, so that the tides at E and F, while high, are not as high as those at A and B, and the low tides at G and H are not as low as the tides C and D.

High tides do not occur regularly every twelve hours, but at intervals of 12 hr. 26 min., *i.e.* if there is a high tide at 9 a.m. the next high tide will be at 9.26 p.m., and the next at

9.52 a.m. This is because the moon is revolving round the sun in the same direction as the earth's rotation. Suppose that X has a high tide (Fig. 64) due to the moon at A. It takes 24 hr. for X to rotate once and come back to its original position. But during this time the moon has moved to position B, so that X has to rotate to Y to experience the high tide again. It takes the moon 28 days to make one complete revolution round the earth, so that XY is $\frac{1}{28}$ of the circumference. If X makes one complete rotation in 24 hr. it will make $\frac{1}{28}$ of a rotation in $\frac{24 \times 60}{28}$ min. = 52 min. approx. But during its rotation, the place X would experience a high tide on the side of the earth away from the moon at *Z*, and this would occur at half of the interval of 24 hr. 52 min., viz. at 12 hr. 26 min.

CHAPTER V

THE AGENTS OF EROSION AND LAND FORMS

Introductory

In Chapter III. reference was made to some of the major land forms of the world, viz. plateaux, plains, and mountains. These have been modelled and sculptured by a number of natural agents so as to produce many types of scenery, and what may be termed the *lesser land forms.* Scenery varies from place to place, both according to the nature of the underlying rock and the agents modifying it. The natural agents responsible for the modelling of the earth's surface are:—

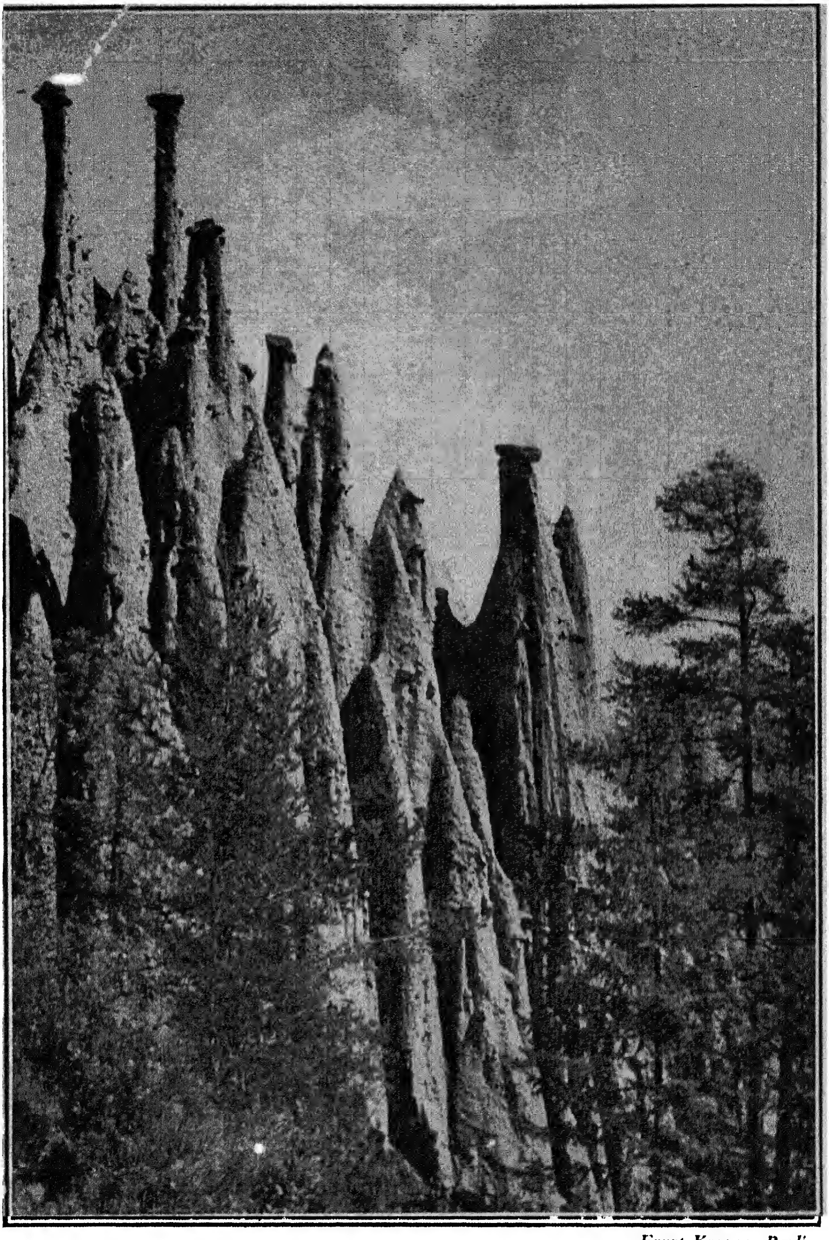
1. The weather.
2. Running water.
3. Ground water.
4. Ice.
5. The wind.
6. The sea (see Chapter VIII.).

The work of these natural agents is threefold. They (*a*) wear away the surface of the land, (*b*) carry away the particles thus removed, and (*c*) deposit the material in some other place. The actual wearing away of the land surface is referred to as *denudation*, or the laying bare of the land. When denudation is the direct result of atmospheric or weather conditions it is referred to as *weathering.*

1. Weathering

Weathering is the process of rock breaking and rock decay produced by the action of rain, temperature changes, frost, and other associated factors. The processes of weathering cause exposed rock surfaces to break and crumble, and in this way material is prepared for transportation by other erosive agents, such as running water, wind, etc. Soils are also formed by the weathering of rock.

(*a*) RAIN.—The work of rain is partly chemical. It dissolves the soluble ingredients of rocks, and washes away



Ernst Krause, Berlin

EARTH PILLARS, NEAR BOLZANO, ITALY.

These have been formed by the action of rain on a stiff clay containing large quantities of stones of various sizes. In this case it is boulder clay. Some of the pillars are capped with large stones which protect the clay beneath from the rain. In time the stone cap falls off, and the pyramid of clay is rapidly worn away.

the loose particles of insoluble material. The work of rain in transporting material and carving out gullies or miniature valleys can be well observed on the pit heaps of mining areas. Here, before a mantle of vegetation has had time to develop, each successive rainstorm, beating on the loosely-piled material, carves the gullies deeper and deeper into the sides of the pit heap. The material thus removed is carried to the foot of the slope, partly by the force of the rain, and partly by its own weight acting under the force of gravity. The sides of many active volcanoes, where the constant deposition of new material prevents the growth of a covering of vegetation show a similar carving into scores of narrow gullies radiating from the mountain top like the spokes of a wheel.

The activity of rain as an erosive agent can be seen in the formation of *earth pillars.* These occur in regions of soft soil or clays, containing scattered blocks of rock. The rain washes away the soft material, except where a small boulder occurs. The boulder protects the underlying soil from the action of the rain. As a result pillars of earth are formed, each one, in the early stages having a " cap " of rock. Earth pillars are not long-lived, for in time the " cap " of rock falls and the rain destroys the " uncapped " softer material. The most famous examples of earth pillars are to be seen near Bolzano in North Italy.

The chemical action of rain is due to the carbon dioxide which it absorbs during its passage through the air. Rain-water is therefore slightly acid. Limestone and other forms of calcium carbonate, such as chalk and marble, are soluble in carbonic acid. In limestone areas the slightly acid water, sinking into the ground, forms huge caverns by a slow process of solution (see page 132).

The chemical action of rain on the felspar in granite leads to the formation of Kaolin or China clay.

(*b*) HEAT AND COLD.—The result of the alternation of heat and cold can best be seen in deserts where there is a great difference between the day and night temperatures (see page 231).

During the day, owing to the power of the sun's rays, exposed rock surfaces are heated rapidly, whilst at night the temperature falls perhaps to freezing point. There is,

CHAPTER VI

LAKES

Formation of Lakes

Lakes are accumulations of water in hollows on the earth's surface. When they are drained by rivers their waters are fresh, but when they have no outlet they are salty, *e.g.* the Dead Sea, Sea of Aral, etc.

Lakes may owe their origin to (1) The formation of a barrier across a river. (2) Earth movements. (3) Volcanic action. (4) Ice erosion.

BARRIERS ACROSS A RIVER.—Barriers across a river valley hold back the water, which forms a lake. Such barriers may be of various types.

(*a*) Sometimes artificial barriers of concrete and masonry are built across a valley in order to make a lake which can act as a reservoir for the water supply of a large city, *e.g.* Lake Vyrnwy for Liverpool.

(*b*) A glacier may deposit a mass of morainic material across a valley. In this way the lakes of the Lake District and many of the Scottish lakes were formed.

(*c*) A landslip may occur. A lake was formed thus in the Upper Ganges valley in 1892. Two years later the landslip dam gave way, and disastrous floods occurred downstream.

(*d*) Oxbow lakes are formed from the meanders of rivers (see page 121). The deposition of silt at the two ends of the " oxbow " closes the channel between the main river and its old loop. Many oxbow lakes border the River Murray in Australia, and the lower Mississippi.

(*e*) Sometimes a lava stream may flow across a valley and cause the formation of a lake, *e.g.* Lake Taupo (New Zealand).

(*f*) Sometimes large estuaries are partially filled with silt. In the portions not so filled are large shallow lagoons. Such lagoons are found in deltaic areas. The Norfolk Broads are portions of an old river estuary.

(*g*) When a silt-laden stream enters a lake its speed is checked and a barrier or delta is built across the lake splitting it into two portions. This has happened in the Lake District, where Keswick stands in the alluvial flats between Lakes Bassenthwaite and Derwentwater, and in Switzerland, where Interlaken is situated in the flats between Lakes Thun and Brienz.

(*h*) The action of the sea often causes an accumulation of sand and pebbles which cuts off a lagoon of sea-water. The Fleet in Dorset is such a lagoon, cut off from the sea by Chesil Bank, a long pebble beach which joins Portland Island to the mainland. The nehrungs of East Prussia are sand spits which enclose the shallow salt-water lagoons or haffs, viz. Kurische Haff (Fig. 88).

EARTH MOVEMENTS.—Earth movements cause lake formation when subsidence occurs. This is most easily seen in rift valleys (see page 127). Examples of rift valley lakes are the Dead Sea, Lakes Nyasa and Tanganyika in Africa, and Lake Torrens in Australia. These are all long, narrow, and very deep lakes. In Cheshire, the removal of underground beds of salt has caused subsidence resulting in the "meres" of the Weaver valley. The "folding" of the earth across the line of a river valley may partially block a river and help to form a lake. The study of a good physical map will reveal the connexion between mountain building (earth folding) and the formation of Lake Geneva and Lake Constance (Switzerland). Where there are large areas of depressed lowland wide and shallow lakes are formed in the lowest part of the depression, viz. the Sea of Aral in Asiatic Russia, Lake Balaton in Hungary, and Lake Eyre in Australia.

GLACIAL ACTION.—Ice sheets and valley glaciers may scoop out hollows to form "rock basins." Mountain tarns and corrie lakes in North Wales and Scotland have been formed in this way. Water also accumulates in the hollows of unevenly-distributed glacial drift. Such are the lakes of East Prussia, and also those of the Cheshire-Shropshire borders near Ellesmere.

VOLCANIC ACTION.—Subsidence of the land surface and consequent lake formation may be directly related to volcanic action. Lough Neagh in Northern Ireland is a shallow lake

formed by subsidence of this type. Lakes are often formed by the accumulation of water in the craters of extinct volcanoes, *e.g.* the Laachersee in the Eifel region of Germany.

The Value of Lakes

On the whole, lakes are of great advantage to man. When large systems of lakes occur such as the Great Lakes of North America, they are of inestimable value in opening up the land and providing a cheap and easy means of transport for bulky commodities.

Lakes help to regulate the flow of rivers, preventing the possibility of excessive flooding or of very low water. Thus, rivers containing lakes are of greater value for transport, water supply, and where necessary (*e.g.* the Yang-tse-Kiang) for irrigation.

Very large lakes help to moderate the climate of the neighbouring country. Because of the westerly breezes from Lake Michigan, its eastern shores have their winter temperature raised so that fruit growing is an important occupation, because the danger of frost is lessened. The western shores of the lake are not so important for fruit.

Large cities depend on lakes for their water supply, viz. Manchester obtains water from Lake Thirlmere in the Lake District. It must also be remembered that lakes add to the beauty of the scenery and so increase the revenue through their attraction for " tourists."

The beds of old lakes are of great importance agriculturally, because of the deep, rich, stoneless soil. The Vale of Pickering in Yorkshire is an old lake bed, and so are the fertile lands in the neighbourhood of Lake Winnipeg in Canada. Lake Winnipeg is the remnant of a much larger lake that once existed there (viz. Lake Agassiz).

CHAPTER VII

VOLCANOES AND VOLCANIC ACTION

Volcanoes and their Eruptions

A volcano is a hole in the earth's crust through which are ejected hot rock, ashes, lava, steam, mud, and various gases. Such holes occur where there is a thinness or weakness in the earth's crust. The materials which are ejected, falling around the hole or crater, gradually build up a mountain that is roughly conical in shape, and has a crater at the top (Fig. 79). Good examples of such mountains are Fuji Yama in Japan, Vesuvius in Italy, and Chimborazo and Cotopaxi in the Andes.

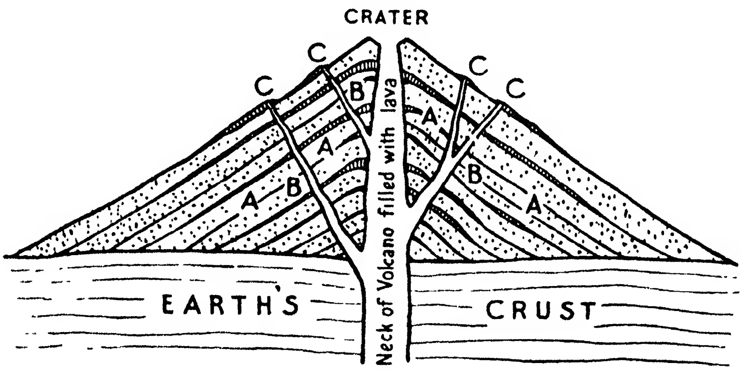


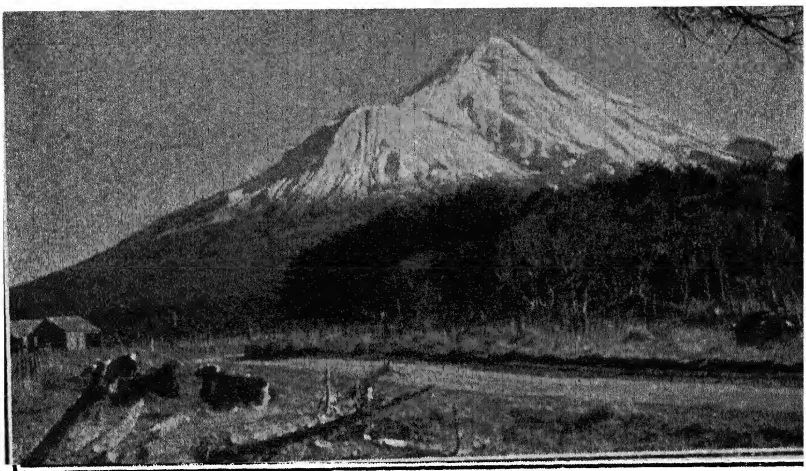
Fig. 79. A Section of a Volcano.—A. Accumulations of volcanic material. B. Secondary lines of lava flow. C. Minor vents or craters.

Volcanoes are said to be *active* when eruptions occur frequently; *dormant* when no eruption has occurred over a long period of years; and *extinct* when no eruption has occurred during historic time. Vesuvius was thought to be extinct, and Krakatoa, too, had never been known to erupt, but both sprang into activity within historic times.

Most eruptions are preceded by tremors or quakings of the earth, called earthquakes. Then there is usually an outburst of steam and gas. From the rising steam, clouds are formed above the volcano, and heavy rainstorms follow, frequently accompanied by thunder and lightning. After this there is

often an explosion, and heated rock is hurled into the air. Lava is forced out of the crater and flows down the mountain sides. The rain, falling on the hot dust ejected by the volcano results in streams of hot mud which are as destructive as the flowing masses of hot lava.

Sometimes volcanic eruptions are of a quieter type and there is no explosion. Lava wells up in the crater and flows quietly down the mountain side. Such volcanoes as these occur in Hawaii (Mauna Loa and Mauna Kea), where the lava often flows fifty miles before it cools and hardens.



High Commissioner for New Zealand

MT. EGMONT FROM STRATFORD

This is an example of a conical volcanic mountain. Notice the secondary cone on the slope of the volcano, the snow-line, and the tree-line above which trees do not grow.

Stromboli, in the Mediterranean, is an example of a volcano which is continuously and moderately active but from which no lava is ejected. Its constant " glow " has earned for it the name " the lighthouse of the Mediterranean."

Possibly the best known example of a violently explosive eruption was that of Krakatoa in 1883. Krakatoa is a small island in the East Indies. The explosion was so violent that it blew away a large portion of the island, the sea now being 1000 ft. deep where the mountain once stood. Dust was hurled more than 20 miles into the air, the explosion was heard in Australia over 2000 miles away, and the vibration

broke windows in Batavia 100 miles away. Gigantic waves were formed which caused the sea to rise 50 ft. on the shores of neighbouring islands. As a result the loss of life was very great, 36,000 people being killed. The dust particles in the atmosphere gave rise to vivid sunsets not only in Asia, but in all parts of the world, during the three following years.

Distribution of Volcanoes

Active volcanoes seem to have a well-defined distribution. Many of them are in mountainous areas, particularly in regions of " new fold " mountains. Many also occur near the sea, or actually in it, rising from submarine ridges, as in the Hawaiian Islands and the West Indies. On the other hand, some volcanoes are not in highland areas, and some are not near the sea (viz. Kilimanjaro in Africa). The most striking feature of their distribution seems to be the ring of volcanoes which surrounds the Pacific Ocean, extending from Mt. Erebus in Antarctica, through the Andes, the Western Cordillera of North America (there is only one active volcano in the United States, viz. Mt. Lassen in California), the Aleutian Islands, Kamchatka, Japan, the East Indies, and New Zealand. This girdle of volcanoes is often referred to as the "Fiery Ring of the Pacific." Outside this ring, active volcanoes are found (*a*) in the West Indies; (*b*) in close association with the African rift valley. There are also a large number of extinct cones throughout the central mountains system of Asia (viz. Mt. Demavend in Persia). A few volcanoes occur on islands, such as Mt. Hekla in Iceland.

Probable Origin of Volcanoes

The belief that volcanoes have their origin in a hot liquid interior of the earth is now considered to be wrong. From observations in mines, etc., it has been found that temperatures increase with depth, and that at a depth of 60 miles the temperatures would be high enough to liquefy rock. But the immense pressure due to the weight of the earth's crust raises the melting point, and it is probable that even at such high temperatures the rocks remain solid. It is now suggested that (1) there is a liquid layer between the solid crust of the earth and a solid and very hot central core; (2) subterranean heat is caused by pressure due to rock folding and to chemical action

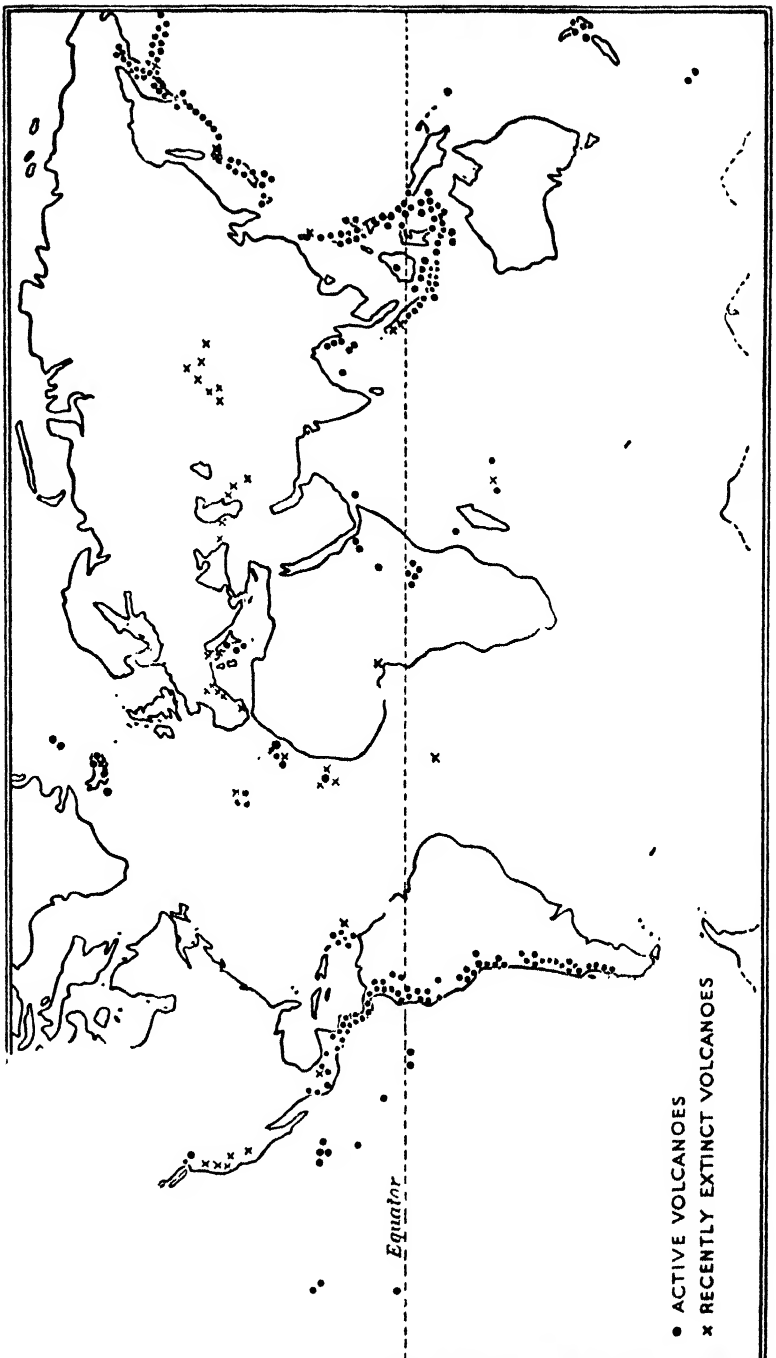


Fig. 80. Map Showing the Distribution of Volcanoes.
Try to locate and name some of the principal peaks in each continent.

between the components of the rocks, and this heat helps to produce liquefaction of rock. The lighter lava would tend to rise above the solid rock until it came near to the surface, when lateral pressure might cause it to flow out at the surface in places where the earth's crust was weakest. Fissure eruptions, such as once occurred in Northern Ireland and the North-West Deccan, and the "quiet" type of eruptions which occur in the Hawaiian Islands are possibly due to this cause.

On the other hand, the expansion and explosive forces of steam and other gases seem to be responsible for eruptions of the "Vesuvius" type.

CHAPTER VIII

COASTS AND ISLANDS

Coastal Types

The line where land and sea meet is known as the coastline. The *general outline* and *major features* of the coast depend on a number of factors such as (*a*) the structure of the land and the trend of the hills and mountains; and (*b*) whether the land has been raised or depressed. *Minor coastal features*, such as "coves," "stacks," etc., are the result of the (1) nature of the rocks, and (2) the erosive force of the sea.

The Effect of Sea Erosion

The continued roll of the waves along a shore line, and the force of the pebbles carried by the waves during storms, causes the coastline to be worn away, particularly where the rocks are relatively soft or where there are lines of weakness. Such action gives rise to alternations of broad bays and steep cliffs, such as Studland and Swanage Bays in Dorset, and with the alternating headlands known as Ballard Pt. and Durlston Head (Fig. 81) the belts of rock of unequal resistance run at rig' the coast. On the south coast of England work of the sea where the rocks run in coast can be observed. As shown fringed by a belt of limestone (A) clays (B), and chalk (C). breached the limestone

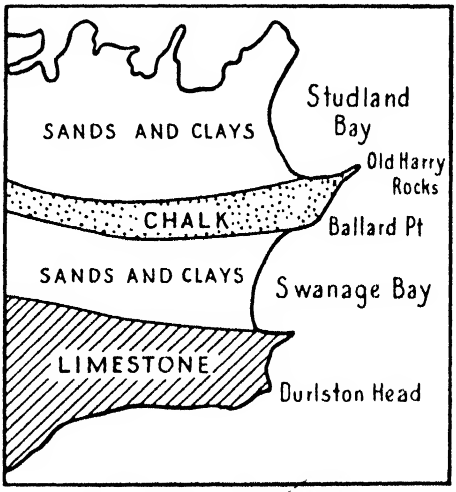


Fig. 81. To Show the Effect of Alternate Belts of Hard and Soft Rock on Coastal Features.

rapid erosion of the soft clays behind the limestone. This erosion is limited inland by the resistant chalk, so that a roughly oval "cove" is formed, such as Lulworth Cove (Fig. 82). Two coves may be extended laterally so that the outer limestone is left standing as small off-shore islands (E). It is the erosive force of the sea that is responsible for such formations as "the Needles," "the Old Man of Hoy," etc.

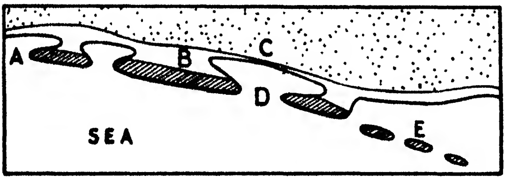


Fig. 82. To Show the Effect on Coastal Erosion of Belts of Rock of Unequal Hardness Parallel to the Coast.

There are natural limits to the formation of coastal openings by sea erosion, for as the waves reach the head of a gulf or bay their speed slackens and the erosive power decreases. Hence there must come a time when an opening due to marine erosion will reach its limit inland. But, at the seaward end of the opening strong waves are still buffeting the cliffs and wearing them away, so that the effect of the sea is to lessen the coastal irregularities rather than to increase them. This can be well seen in the bays near Torquay where there are "bay head" beaches, and also at the heads of many of the openings on the west coasts of Scotland and Ireland.

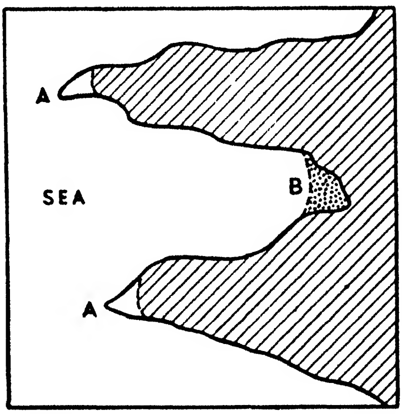
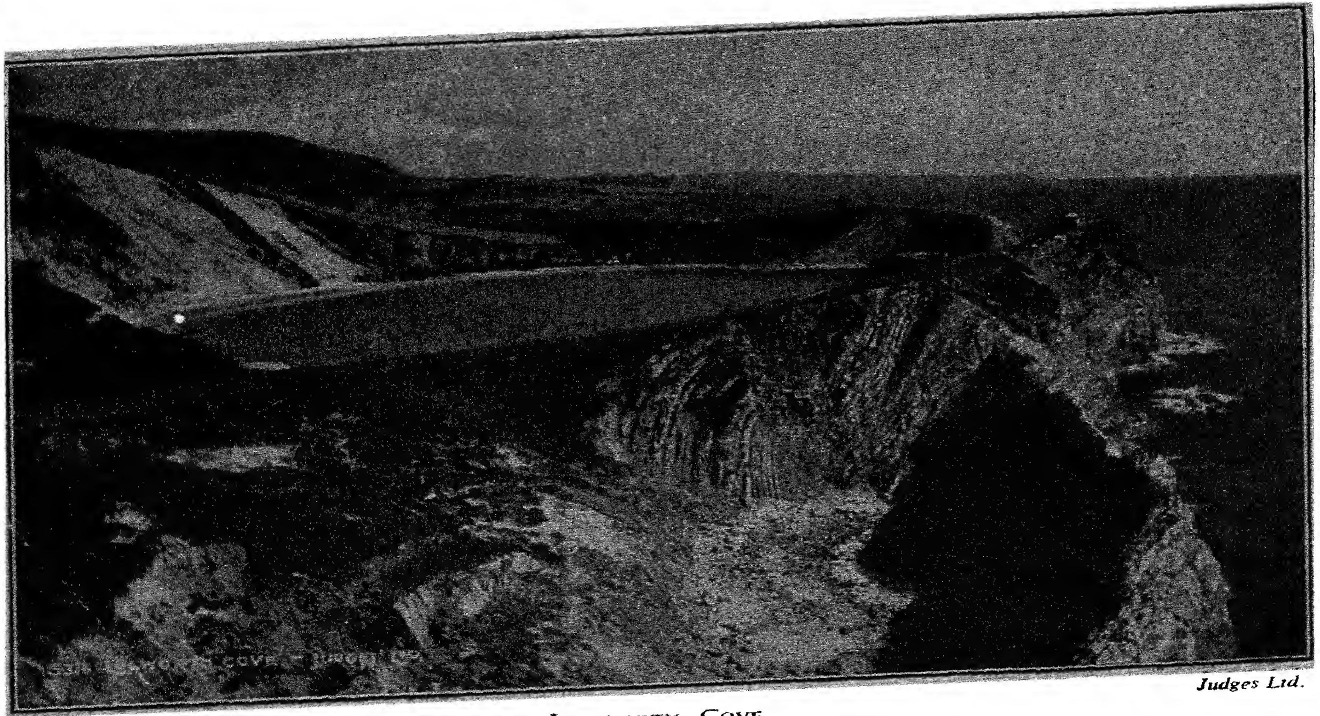


Fig. 83. To Show the Effect of Marine Erosion.

Fig. 83 illustrates marine ...ion wearing back the cliffs ...ut at B the sea has ...r to erode, and filling up the ...ng by the deposition of fine material ...nudation of the sea cliffs) which ...the sea currents. In such a way some of the minor irregu-



Judges Ltd.

LULWORTH COVE.

On the extreme left is the chalk ridge, and on the right fringing the sea, a narrow belt of limestone. The sea, having breached the limestone, has eroded the intermediate belt of softer rocks into an almost circular cove. In the foreground the rocks of the Stair Hole provide a good example of both stratification and rock folding. (See Fig. 82.)

Constructive Action of the Sea

The constructive action of the sea includes the formation of sand-spits and sand-bars across the mouths of rivers. Sand-spits and lines of sandy islands are of frequent occurrence in East Prussia (the Haff coastline, Fig. 88), the Frisian islands, on the east and south coasts of the United States (*e.g.* Cape Hatteras), on the south coast of France to the west of the Rhone delta, and on the east coast of S. America (*e.g.* L. Patos).

In England a notable example of the constructive work of the sea is Chesil Bank, a bank of shingle which cuts off a shallow lagoon known as the Fleet, and links Portland Isle with the mainland. The Great Orme at Llandudno was probably joined to the mainland in a similar way.

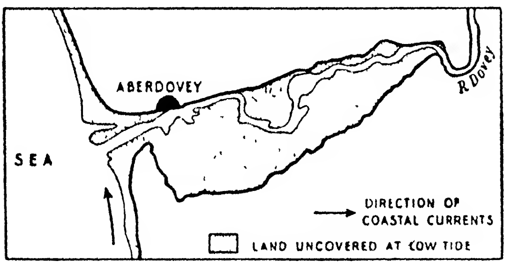


Fig. 84. To Show the Effect of Tidal Currents on Coastal Formation.

The estuaries of rivers flowing into Cardigan Bay are characterised by north-pointing sand-spits which partly block the seaward end of the estuary and push the course of the river northward (Fig. 84). This is apparent in the estuaries of the Dovey, Mawddach, and many smaller rivers. There, the coastal currents are north-flowing, but on the east coast where the currents flow south, there are similar, but south-trending, sand-spits, *e.g.* at the mouths of the Yare, Alde, Stour, etc.

Major Coastal Features

Such minor coastal features as have already been referred to are only apparent in maps of great detail, such as the "one-inch" Ordnance Survey Maps of Great Britain. On atlas maps only the major characteristics of a coastline are shown, and these generally are the result of factors other than sea erosion, though the latter plays its part in producing the detailed sculpturing of every coastal type.

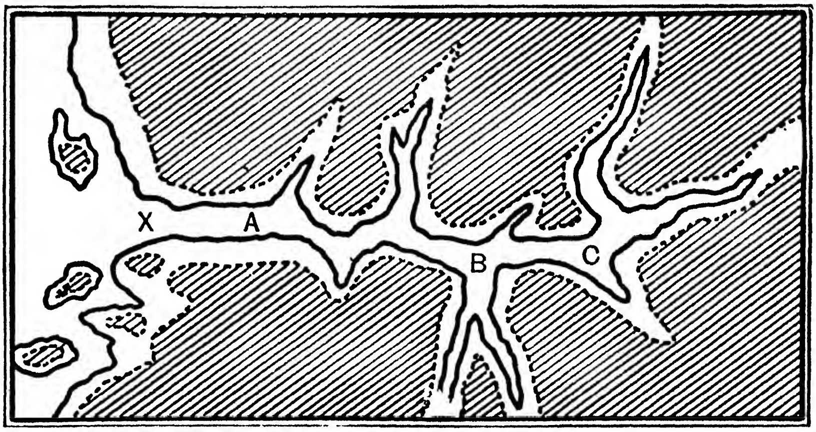


Fig. 85. A FIORD.—Shows how the highland comes close to the fiord side. X is shallower than A, B, C.

The following are some of the principal coastal types:—

(1) The Fiord coastline.
(2) The Ria coastline.
(3) The Dalmatian coastline.
(4) The Haff coastline.

(1) THE FIORD COASTLINE (Fig. 85).—On the coast of Norway or Western Scotland are a large number of long, narrow inlets with very steep sides. These are called *fiords*. They are usually shallower at their seaward end than they are at their landward end. These inlets have been formed by the gradual sinking of the land so that the sea has covered the lower or valley areas. Thus they are a type of drowned valley. The excessive steepness of the sides may be due to erosion by ice, which produces a steep-sided U-shaped valley, or to faulting.

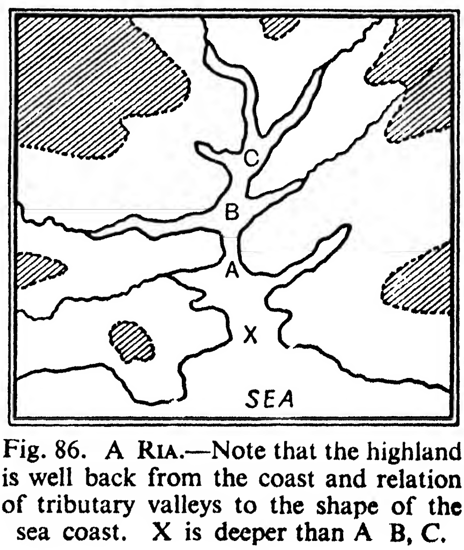


Fig. 86. A RIA.—Note that the highland is well back from the coast and relation of tributary valleys to the shape of the sea coast. X is deeper than A B, C.

Such openings form good sheltered harbours, but since the fiord sides are steep and communication inland is difficult, and since the land behind the coast is unproductive, fiord coasts such as those of western Scotland, have few important ports. The length of the Sogne Fiord is equal to the distance from London to Bristol.

(2) THE RIA COASTLINE (Fig. 86).—Rias are also drowned valleys, but since they have not been previously glaciated, the sides are more gently sloping and access inland is easier. The openings in S.W. Ireland, such as Bantry Bay, and in Cornwall, such as Plymouth Sound and Falmouth Harbour, are good examples of rias. Not only the main river valley, but the tributary valleys also, have been drowned, giving these openings a complicated "branching" shape.

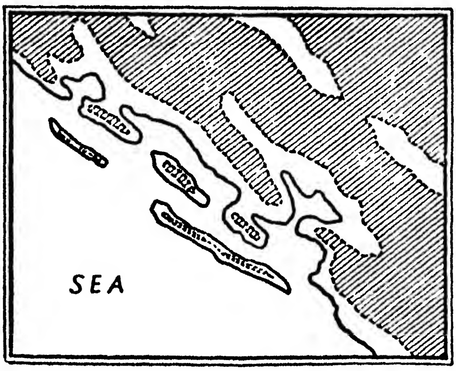


Fig. 87. DALMATIAN TYPE OF COAST. Note the shape of openings and islands and the relation of the highland to the coast.

(3) THE DALMATIAN COASTLINE (Fig. 87).—The eastern coast of the Adriatic Sea offers a good example of the way in which the nature of the land influences the type of coastline. Here the mountain chains run in a N.W.-S.E. direction, parallel to the shore. The area has been "drowned," so that the narrow entrances which open out into broad inlets parallel to the main trend of the coastline. The islands off-shore are really the submerged tops of mountain ranges. These islands are hilly, long, and narrow, and parallel to the shore.

(4) THE HAFF COASTLINE (Fig. 88).—Some coastlines are low and unindented. The coastline of East Prussia consists of a series of narrow strips of land running roughly parallel to the coast. These strips are really large sand dunes, and they cut off shallow lagoons called, in Germany, "haffs." In time these lagoons are completely filled by wind-blown sand and by silt deposited by the rivers flowing in from the

land. This results in a coast type like that south of the Garonne in France, or similar to the short strip of the Somersetshire coast lying south of Weston-super-Mare. On some coasts, such as those of the north of Holland, a line of long and narrow, low sandy islands runs parallel to the shore. These coastlines offer no good harbourage, but are usually backed by extensive plains which are productive and do not hinder communication.

Islands

Islands are often classified as (*a*) Continental; (*b*) Oceanic.

CONTINENTAL ISLANDS.—This is the name applied to those islands which :—

(1) Lie near to the shores of a continent.

(2) Are a continuation of the same rocks and structure as the continental mainland.

(3) Are usually separated from the mainland mass by shallow seas (*i.e.* under 600 ft. in depth).

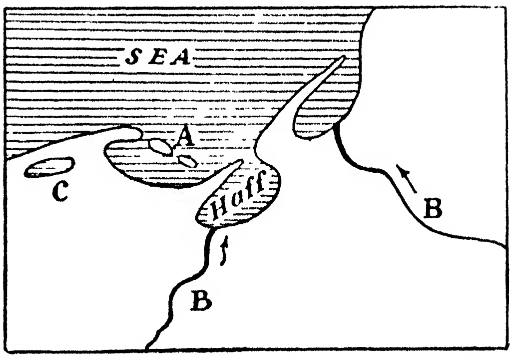


Fig. 88. SAND DUNE COAST.—A. Sandy Islands. B. Rivers bringing down silt. C. Lagoon (remnant of an old haff).

Most continental islands rise from the bordering continental shelf, *e.g.* the British Isles, and Newfoundland. Some, however, while rising from deeper water, may have definite structural links with the continent, *e.g.* the East Indies are a continuation of the Asiatic " fold " mountain system, as is Sicily of the European " folds." It can generally be assumed that continental islands have, at some stage in their physical history, been joined to the adjacent mainland. Madagascar is an interesting example of an island which has been separated from the mainland for a very long period, for although it is divided from Africa by the wide and deep (nearly two miles) Mozambique straits, a study of its rock formation and its animal life suggest its former connexion with Africa.

OCEANIC ISLANDS.—These, on the other hand, lie in the open ocean at great distances from the continents. Their structure bears no relation to the nearest shores, and they rise from the ocean depths. They may be the tops of submarine ridges (see page 91). Thus Ascension, Fernando Po rise from the Central Atlantic Ridge. Other oceanic islands may be of volcanic formation, viz. St. Helena and Teneriffe.

Yet another group of oceanic islands are those of coral formation. Coral is a limestone deposit formed by the accumulation of the "hard parts" or skeletons of the coral polyps —a minute sea organism.

The reef-building coral is limited in its distribution, for it can only flourish under the following circumstances:—

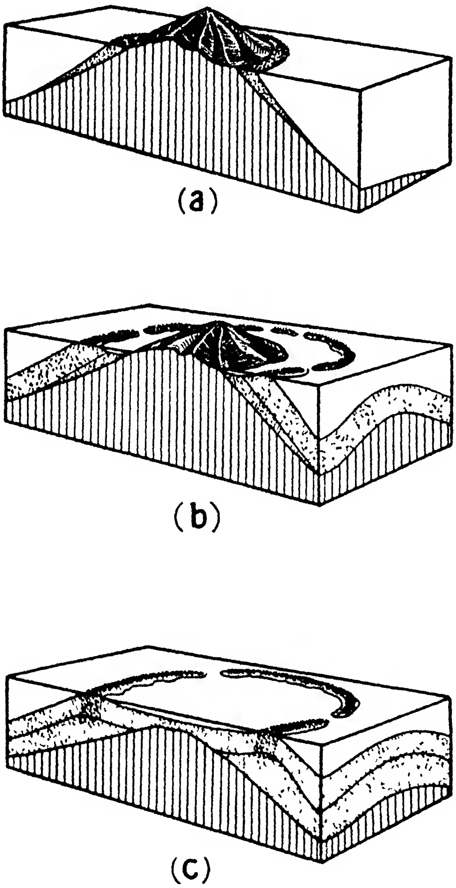


Fig. 89. CORAL ISLANDS.—(*a*) A fringing reef. (*b*) A barrier reef. (*c*) A large atoll.

(1) The temperature of the sea must be about 70° F. Such a sea temperature is rarely found beyond 30° N. and 30° S. Within these limits, ocean temperatures are higher on the east of continents than on the west (see page 97), hence coral islands are usually found off *the eastern coasts of continents within the Tropics.*

(2) As temperature decreases with depth, the coral polyps cannot live below a depth of about 150 ft. The coral therefore lives in shallow inshore water.

(3) The coral polyps cannot flourish in fresh water (*i.e.* near the mouths of rivers) because such water does not contain the necessary salts.

(4) Coral does not live in silt-laden water such as is brought down to the sea by rivers.

Low, circular coral islands with a central lagoon of shallow water are known as "atolls." There are many theories to explain the formation of such islands. That of Charles Darwin is the one most generally accepted. His theory stated that the coral began to build a reef around an island [Fig. 89(*a*)]. Such a reef, contiguous to the shore, is known as a "fringing reef."

He assumed that the island then sank, and that the coral continued building upwards [Fig. 89(*b*)] so that the coral reef is separated from the island by a "lagoon" of shallow water. At this stage the reef is known as a "barrier reef."

Further subsidence causes the island to "disappear," but as the coral building still proceeds a circular ring of coral is left, known as an "atoll" [Fig. 89(*c*)]. Such islands only rise a few feet above sea-level. In course of time the coral limestone is weathered into soil, then seeds, possibly carried by birds, germinate and gradually permanent vegetation is established. The coconut palm is the most typical plant of such islands.

Darwin's explanation of the formation of atolls is not accepted by all scientists, and his theory certainly does not explain the occurrence of atolls in places where subsidence has not taken place, for there the coral may have built upwards from slightly submerged mountain tops or plateaux.

CHAPTER IX

CLIMATIC FACTORS—I. TEMPERATURE

Introductory

" Climate " should not be confused with " weather." The *climate* of a place may be defined as the *average* conditions of temperature, rainfall, humidity, winds, sunshine, and cloudiness typical of that place.

The state of the temperature, rainfall, etc., at a given time, and its deviations from the average conditions constitute the *weather* of a place. Variations from the average conditions, *i.e.* change in the weather, are most common in temperate latitudes.

The study of climate should include consideration of (1) the average temperature and (2) the annual range of temperature; (3) the total annual rainfall; (4) the seasonal distribution of the rainfall; (5) the prevalent winds; and (6) the amount of sunshine and cloudiness.

Temperature is recorded by thermometers. The Fahrenheit thermometer (freezing point 32° and boiling point 212°) is most generally used for weather observations, and the Centigrade (freezing point 0° and boiling point 100°) for other scientific purposes.

The Recording of Temperature

The required thermometers are placed in a special screen known as a Stevenson screen, so constructed as to allow free passage of the air around the thermometers, but protecting them from the direct rays of the sun. In this way the shade temperature of the air is obtained.

A maximum thermometer records the highest temperature for the day, whilst a minimum thermometer records the lowest temperature. The mean or average of these two readings is the mean temperature for that particular day. This process is repeated for every day of the year, and the average of the daily readings is calculated. The result thus obtained is the mean temperature for that particular year, which may, perhaps, have been abnormally hot or cold.

Therefore, these annual results are collected for a period of thirty to forty years, and the average again found. This final result is the Mean Annual Temperature of a given place. It is obvious that the collection of such data has involved an immense amount of work, and during the last half-century, in England, the records have been obtained largely by voluntary enthusiasts.

The Mean July Temperature is obtained by taking the daily maximum and minimum temperatures for the month of July and finding the average. Then similar data for the months of July in preceding years are collected and the average found. The Mean January Temperature is obtained in a similar way.

ISOTHERM MAPS.—When temperature data have been collected for a great number of places they are reduced to sea-level, plotted on a map, and lines drawn joining all places of the same temperature. These lines are called *isotherms*. Thus maps are constructed to show the January, July, and annual temperatures of any country. In many remote parts of the world, such as Central Siberia or the Amazon Basin, there are very few observation stations for the collection of climatic data, hence maps for such areas are not absolutely correct, but serve quite well for general purposes.

Factors Affecting Temperature

The temperature of a place depends on the following factors: (*a*) Latitude; (*b*) Altitude; (*c*) Distance from the sea; (*d*) Prevailing winds; (*e*) Ocean currents; (*f*) Clouds and rainfall; (*g*) Slope of the land.

(*a*) LATITUDE.—On an average, temperature decreases from the equator to the poles. This is because as we go nearer the poles the sun's rays fall more obliquely on the earth's surface. Study Fig. 90 carefully. Suppose X and Y are two bundles of the sun's rays of equal thickness, *i.e.* with the same heating power, striking the earth in March or September. The rays X meet the earth at the equator at right angles, but the rays Y meet the earth at CD at an angle much less than a right angle (angle Q).

Now the bundle of rays X, has to heat the shaded area AB, while the bundle of rays Y, has to heat the shaded area CD. But AB is much smaller than CD, and since the heat applied

is the same in both cases, it follows that the area AB near the equator must be hotter than the area CD nearer the poles.

Again, the bundle of rays Y, because of their obliquity, have a longer passage through the atmosphere than the rays X (EC is longer than AF). Thus, more of the energy of the sun's rays will be absorbed by particles of moisture, dust, etc., so that when the sun's rays Y ultimately reach the earth they will have been deprived of more of their heating power than the bundle of rays X. (Note that these same principles may be applied to the heating power of the sun at midday, sunrise, and sunset. At midday the rays of the sun strike the

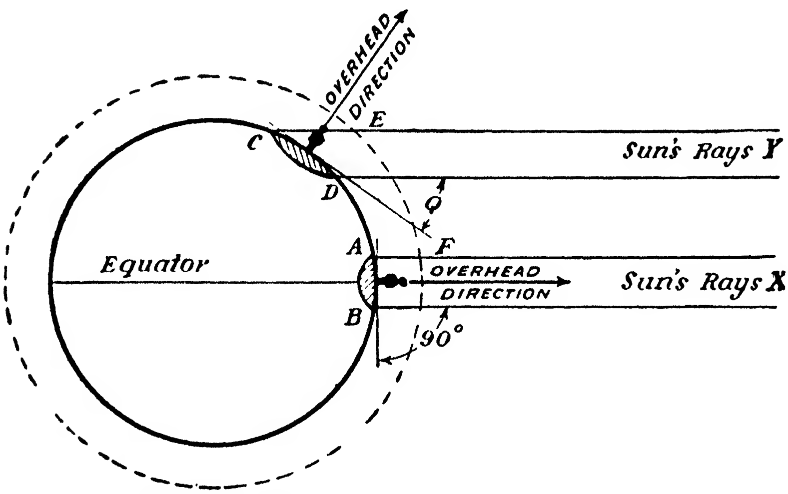


Fig. 90. THE DOTTED LINE DENOTES THE BELT OF ATMOSPHERE AROUND THE EARTH.

earth less obliquely than in the morning or evening. Also when the sun is low in the sky its rays have to pass through the atmosphere for a greater distance in the evening than at midday.)

(*b*) ALTITUDE.—Temperature usually decreases as one goes upward from the earth, roughly at the rate of 1° F. for every 300 ft. For instance, a mountain 3600 ft. high would be 12° F. colder at the top than at the bottom. Snow remains unmelted on mountain tops when there is no snow on the plains. It may be thought that the mountain top, being nearer to the sun, should be warmer, but the sun's rays do not heat the air directly. They heat the earth, and the warmed earth

in turn heats the atmosphere, so that the nearer one is to the earth the warmer it is. But, of course, it may be argued that the top of a mountain, being part of the earth's surface, is warmed by the sun and also heats the air around it. This is certainly true, but as one goes upwards the air becomes less and less dense (see Fig. 91), and so the heat given off by the warmed earth passes quickly away through the thinner atmosphere, which consequently remains cold.

(*c*) Distance from the Sea.—During the summer the sun, shining on land and sea, warms both, but the sea does not become as warm as the land. Hence, if a place is near the sea, a wind from the sea will bring cool air in summer and lower the temperature, while a place situated inland away from the sea will be hotter.

In winter the land loses the heat it has gained during the summer much more quickly than the sea, so that in winter the sea is warmer than the land. Therefore, in winter, sea breezes will carry warm air to the land and raise the temperature of places near the coast, while places inland will be colder.

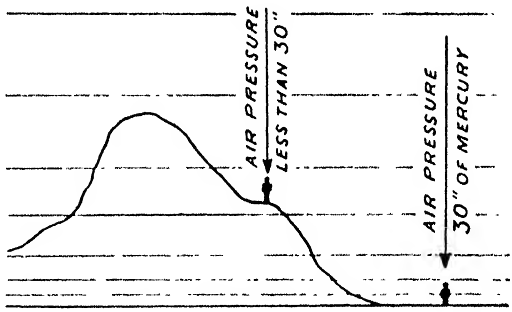


Fig. 91. The Atmosphere Becomes Less Dense as One Ascends.

Valentia, in S.W. Ireland, has a summer temperature of 59° F. and a winter temperature of 45° F., while Tomsk, in Central Siberia, and nearly in the same latitude as Valentia, has a summer temperature of 66° F. and a winter temperature of − 3° F. (*i.e.* 35° below freezing point). Valentia has a range of 14° F., while Tomsk has a range of 69° F. We refer to the climate of Valentia as *Insular*, *Maritime*, or *Oceanic*, while we speak of the climate of Tomsk as *Continental* or *Extreme*.

Maritime climates are found in islands, and in coastal regions where the prevailing wind blows from the sea. (These climates also have heavy rainfall throughout the year.)

Continental climates are found in temperate latitudes in areas remote from the sea, or even in coastal regions where the winds blow from the land. (These areas have less rainfall than maritime areas, and the rain falls mainly in the summer.)

(*d*) PREVAILING WINDS.—The effect of prevailing winds in determining the temperature of a place depends on the nature of the region from which the wind blows. A wind from the sea lowers the summer and raises the winter temperature, *e.g.* the westerly winds of the British Isles. A wind from the land lowers the winter temperature and raises the summer temperature, *e.g.* Manchukuo has very cold winters because the prevailing winter wind blows from Central Asia.

(*e*) OCEAN CURRENTS.—Ocean currents modify the temperature of winds blowing over them, *i.e.* a wind which has passed over a warm current will have its temperature raised, and one which passes over a cold current will have its temperature lowered. The general statement that warm currents raise, and cold currents lower, the temperatures of neighbouring lands is not entirely correct. The power of the currents to affect the temperature depends very largely on the direction of the prevailing winds. Off the east coast of the United States, for instance, there is a warm current, the Gulf Stream. In summer, when the winds are mostly on-shore, the effect of the current is to raise the temperature (and the rainfall), but in winter, when the winds mostly blow off-shore, the current has little effect. In Labrador the cold current has little effect in winter, when the winds are mainly off-shore, but it has a chilling effect on the summers (and reduces the rainfall) when the winds are mainly on-shore. These general principles can be applied in relation to the effects of any ocean currents on the climates of their neighbouring shore lands.

(*f*) CLOUDS AND RAINFALL.—Heavy rainfall accompanied by dense cloud, obscures the sun and thus reduces the temperature. On the other hand, in regions of little cloud and free radiation such as desert areas, very high day temperatures are recorded. Since there is no layer of cloud (" cloud blanket ") to prevent the free radiation of heat, night temperatures fall rapidly, and such districts have a very high diurnal (daily) range of temperature.

(g) SLOPE OF THE LAND.—South-facing slopes are warmer than north-facing slopes, partly because the northern slopes are exposed to cold north winds while southern slopes are sheltered from them, and partly because the rays of the sun strike south-facing slopes at a steeper angle than they do the northern slopes. In Fig. 92, AB, a smaller area, receives the same heating power as does CD, a larger area, and this is clearly due to the angle between the slope of the surface of the earth and the rays of the sun.

Factors Affecting Range of Temperature

The difference between the mean temperature of the hottest month and the mean temperature of the coldest month is called the Mean Annual Range of Temperature.

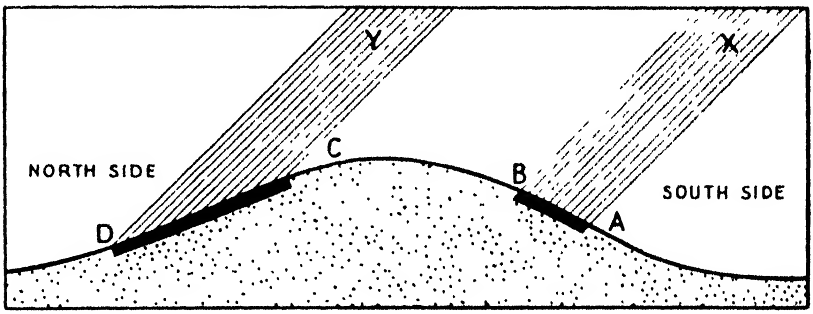


Fig. 92. TO SHOW WHY SLOPES FACING THE SUN ARE HOTTEST.

For instance, the mean July temperature of London is 64° F., and the mean January temperature is 38° F. Therefore the Mean Annual Range of Temperature for London is 64° − 38° = 26° F.

The difference between the maximum and minimum temperatures of any one day is termed the Diurnal Range of Temperature. The hottest part of the day is after midday, usually between 1 p.m. and 2 p.m., and the coldest part of the day is generally about half an hour before sunrise.

The principal factors affecting the mean annual range of temperature are: (1) Latitude; (2) Distance from the sea; (3) Prevailing winds; (4) Ocean currents; (5) Cloudiness.

(1) LATITUDE.—In general the annual range of temperature increases from the equator to the poles. This is because the

difference between the amount of heat received from the sun during its periods of maximum and minimum elevation is least at the equator and greatest at the poles. In other words, it is always hot at the equator where the sun is always high in the heavens, so that there is little difference between the mean temperature of the hottest and coldest months. At the poles the sun shines for six months, and for almost six months it is below the horizon, thus there is a great difference in the amount of heat received during summer and winter, and consequently there should be a large range of temperature.

Other factors, however, come into play, so that the greatest ranges of temperature are not found at the pole but in the cool temperate regions about latitude 60° N.

Because the polar regions are snow-covered, much of the energy of the sun's rays is spent in melting part of the surface snow, and thus the permanent snow-covering keeps the summer temperatures low, so that the range of temperature is not as great as would be expected.

(2) Distance from the Sea.—Land becomes hot more quickly than the sea, and also cools more quickly. Places near to the sea are cooler in summer and warmer in winter. The annual range of temperature is therefore decreased. In general, it may be said that islands have a smaller range of temperature than the interior of continents *in the same latitude*. The smallest range in temperature in the British Isles, in temperate latitudes, is, however, greater than the greatest range of temperature in the Amazon Basin, in equatorial latitudes.

Coastal areas also have a smaller range than the interior of land masses. Thorshaven, in the Faroe Islands, has an annual range of 14° F., while Yakutsk, in the same latitude in Central Asia, has a range of 110° F. It is interesting to note how the range of temperature increases from the sea inland along a given line of latitude.

The following places are almost exactly in the same latitude north of the equator, but each in turn is further from the Atlantic than the preceding one. As the distance from the ocean increases, the summer temperatures increase, and the winter temperatures decrease, so that the range of temperature gradually increases.

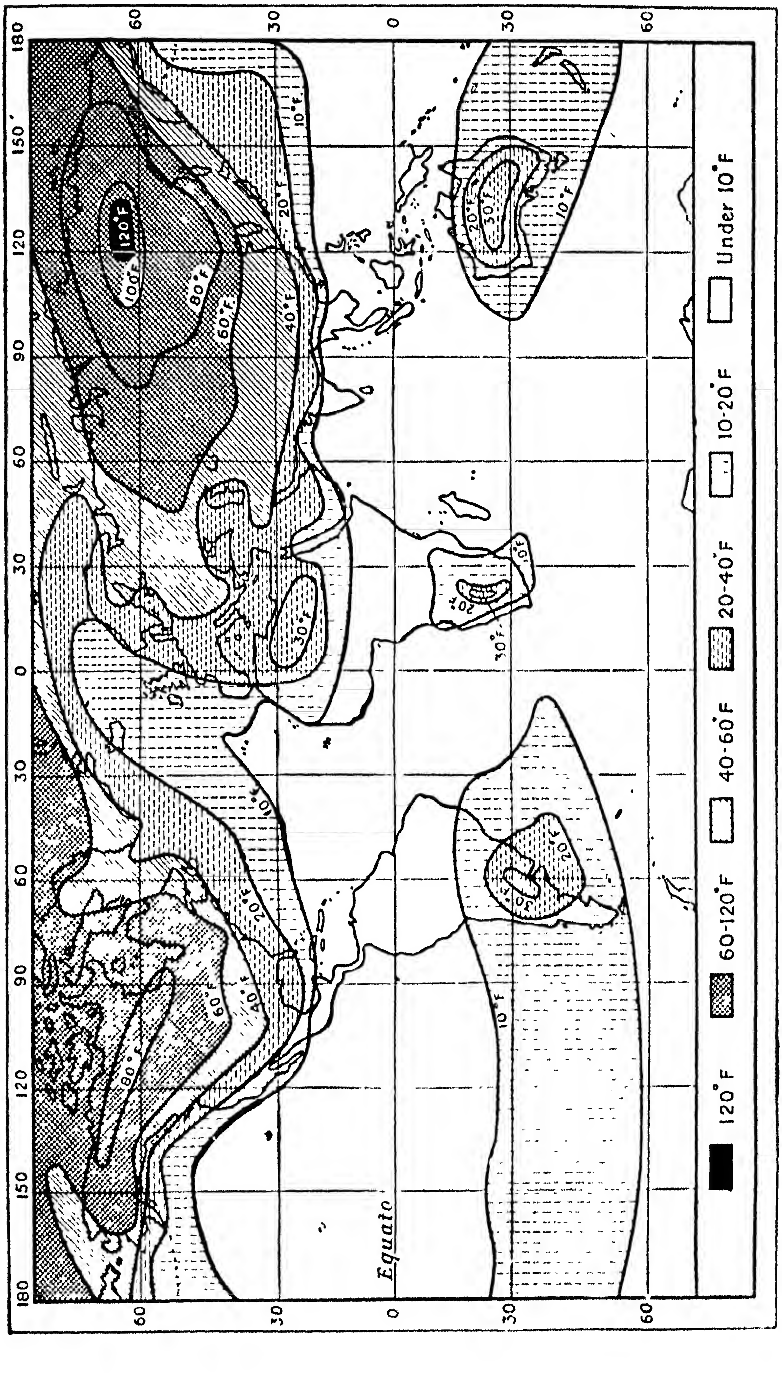


Fig. 93. MEAN ANNUAL RANGE OF TEMPERATURE.

	Summer	Winter	Range
Valentia	59° F.	44° F.	15° F.
Cambridge	62° F.	37° F.	25° F.
Hanover	63° F.	33° F.	30° F.
Berlin...	65° F.	31° F.	34° F.
Warsaw	66° F.	26° F.	40° F.
Orenburg	71° F.	3° F.	68° F.

Note that the summer temperatures increase less rapidly than the winter temperatures decrease, showing that the sea has a greater moderating effect in winter than in summer.

(3) Other Factors Affecting Range of Temperature.—Prevailing winds, ocean currents, and cloudiness affect range of temperature in so far as they raise or lower the temperatures of any given place. British Columbia, which has prevailing winds from the sea at all seasons, has a lower range than Labrador, which has winds mainly from the sea in summer and mainly from the cold land in winter.

To sum up, it will be seen on the map (Fig. 93) that :—

(1) *Low ranges* of temperature occur (*a*) in equatorial latitudes (whether near the sea or inland); (*b*) on islands or coastal areas in other latitudes.

(2) *Large ranges* occur in the centre of land masses in the temperate zone. As, however, the land masses of the temperate zone of the southern hemisphere are narrow, no places are far removed from sea influence, and the largest range of the southern hemisphere is 32° F. in Western Argentina (San Juan). Contrast this with the range of temperature at Verkhoyansk in Siberia (60° F. to − 60° F., *i.e.* a range of 120° F.). Extensive areas of large annual range are confined to the Northern Hemisphere, *i.e.* Central Eurasia and Central N. America.

(3) In the temperate zone the east side of a continent has a larger range than the west side of the continent, due to the greater severity of the eastern winters. The river Pei-Ho, at

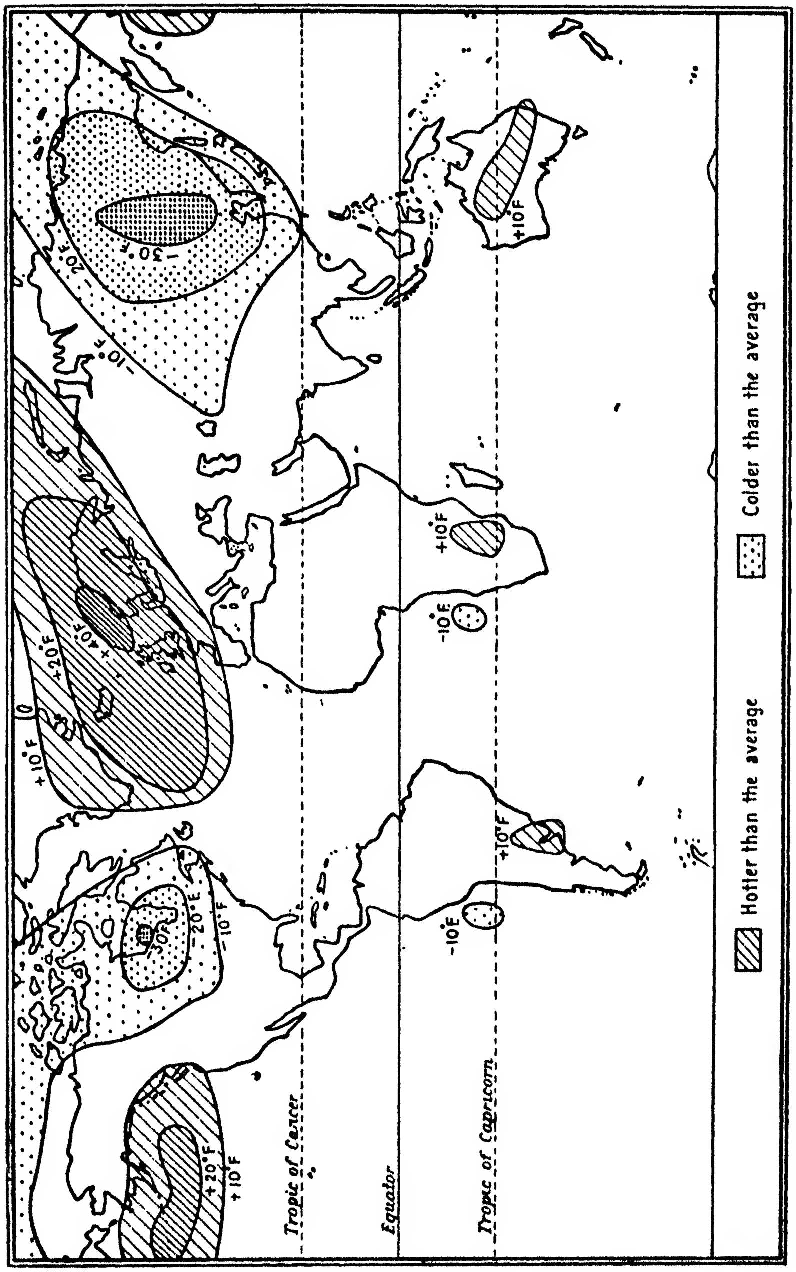


Fig. 94. To Show Areas Hotter and Colder than the Average for the Latitude in January.

Peking, freezes every winter, but the River Tagus at Lisbon, even though it is in the same latitude, does not freeze.

Regions with Temperatures Higher or Lower than the Average for the Latitude

Broadly speaking, temperature decreases polewards, but the rate of decrease, owing to the influence of land and sea distribution, is not constant. Therefore certain areas have summer or winter temperatures which are considerably warmer or colder than the average temperatures of the latitudes in which they lie. In the southern hemisphere where the ocean predominates, the deviations from the normal both in January and July are less pronounced.

(i) JANUARY (Fig. 94).—(*a*) In January *the northern hemisphere* experiences winter conditions, so that the land masses of the temperate zone will be colder than the oceans. There are two areas, which, owing to oceanic warmth have temperatures considerably above the normal. These lie in the east of the North Pacific Ocean and in the east of the North Atlantic Ocean. The latter, because of its very high winter temperatures for the latitude, is often referred to as the "Gulf of Winter Warmth" (note the shape of the 32° F. isotherm for January).

In contrast, the central and eastern portions of North America and Eurasia are regions of excessive cold, because they are removed from the warming oceanic influences of the westerly winds.

The easterly position of the warm and cold areas over both oceans and continents is due (*a*) partly to the westerly winds which lose their moderating influences as they blow eastward over the land, and (*b*) partly to the occurrence of warm and cold currents (see Fig. 60). In temperate latitudes cold currents lower the temperature on the west of the ocean, and warm currents raise the temperature on the east of the ocean (cf. the coasts of Eastern Canada and North-West Europe).

(*b*) In January *the southern hemisphere* is experiencing summer conditions so that the land masses are warmer than the ocean. Areas of excessive warmth occur over the three southern continents, but they are not so extensive as those of the northern hemisphere, and differ much less from the

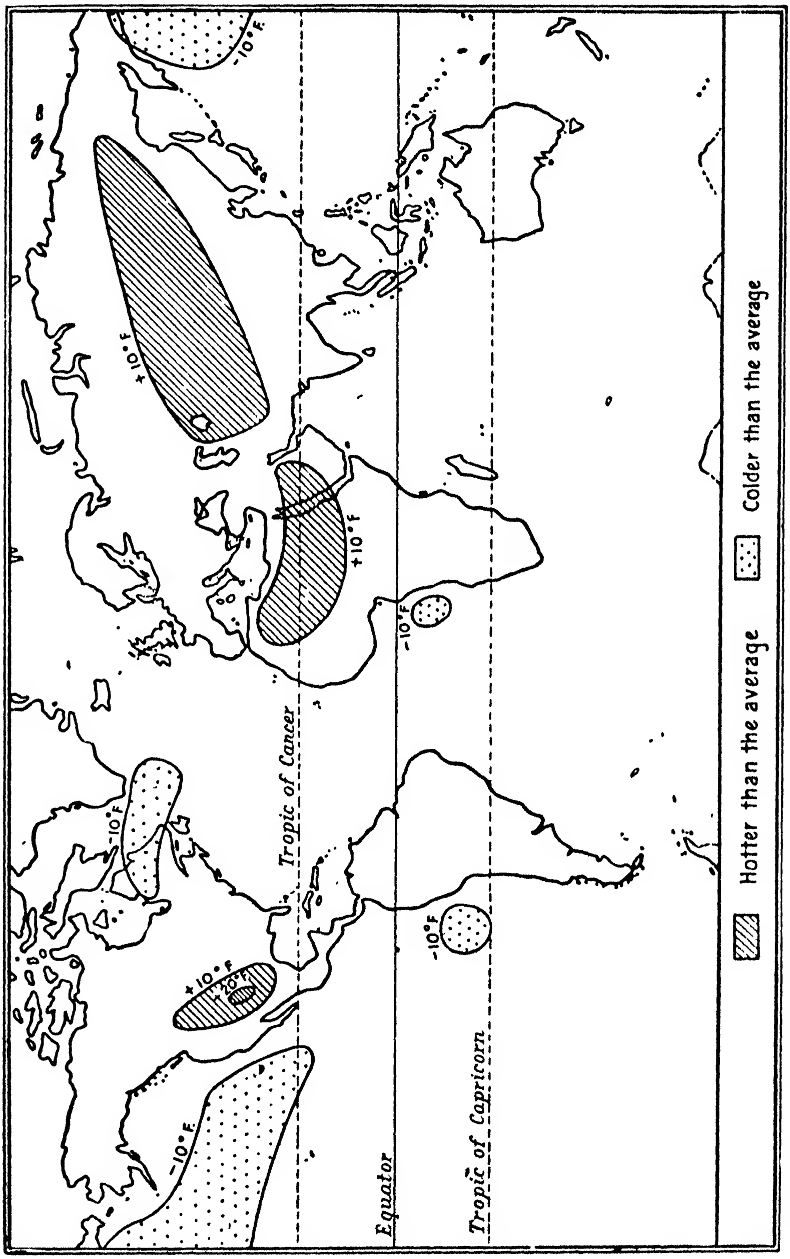


Fig. 95. To Show the Regions Hotter and Colder than the Average for the Latitude in July.

average temperature for the latitude. This is because oceanic influences are strong in the southern hemisphere.

Small areas of relative coldness occur to the west of both South America and Africa in the regions of cold north-flowing currents (Fig. 60), but there is no corresponding area to the west of Australia. This is because warm equatorial currents flowing westward to the north of Australia, minimise the coldness of the Westralian Current.

(ii) JULY (Fig. 95).—(*a*) In July in *the northern hemisphere* summer conditions prevail, so that the land masses are hotter than the oceans.

Areas of exceptional warmth are to be found over Central Asia, North Africa, and the west of U.S.A. Cool regions occur over the North Pacific and the North-West Atlantic. The effect of the cold currents of the temperate zone can be again observed.

(*b*) In July in *the southern hemisphere* it is winter, and it would naturally be expected that there would be cold areas over the land masses and relatively warm areas over the oceans. This, however, does not occur, because the southern oceans are so extensive and the land masses relatively small. Therefore the continents do not experience conditions of winter cold comparable to those of the winters of the north temperate zone. Areas of abnormal cold are absent from the land masses, but occur over the ocean to the west of South America and Africa in the regions of the cold currents as in January. As in January also, there is no corresponding cold area to the west of Australia.

CHAPTER X

CLIMATIC FACTORS—II. RAINFALL

Measurement of Rainfall

Rainfall is measured in inches. " One inch of rain " is the amount of rain it would take to cover a uniformly flat surface with water to the depth of one inch, provided that none evaporated, drained away, or sank into the ground. A snowfall, one foot in depth, is roughly equivalent to one inch of rain.

An inch of rain represents a very heavy fall of rain, and it is exceptional in England for places to record an inch of rain in one day, though in summer thunderstorms such results may be recorded.

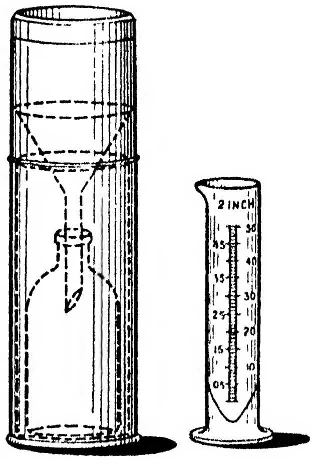


Fig. 96. Rain Gauge (Snowdon Pattern) and Measuring Glass.

Rainfall is measured by means of a rain gauge (Fig. 96). This consists of a round vessel placed in an open position, *i.e.* not sheltered by walls, houses, etc. The top of the vessel is funnel-shaped so that the rain is directed into a bottle. Each morning the bottle is removed and the contents emptied into a special measuring-jar, so marked that it reads as " one inch " the amount of rain it would take to cover the area of the top of the rain gauge to the depth of one inch. Because the measuring-jar is elongated it is possible to read the rainfall correctly to ·01 in.

The daily records are added for the year, and the result is the total rainfall for one particular year. As that year may have been exceptionally wet or dry the totals for 30 to 40 years are taken and the average obtained. This final result is the Mean Annual Rainfall of a given place. As in the case of temperature and pressure, the results are inserted on maps, and lines are drawn joining all places with the same rainfall. Such lines are called *Isohyets*.

Causes of Rainfall

Actually there is one general cause of rainfall, viz. the cooling of air saturated with water vapour. The cooling process, however, may be due to various causes. Air which holds as much moisture as possible is said to be saturated. When this occurs and the air holds 100 per cent. of the moisture it is capable of holding, the *relative humidity* of the air is 100. If the air at a given temperature holds only 50 per cent. of the water vapour it is capable of carrying, then the relative humidity is 50. Warm air, however, can hold more moisture than cold air, so that the actual amount of moisture required to saturate air at a low temperature (*i.e.* to give a relative humidity of 100) may only be three-quarters of the amount required to saturate an equal volume of air at a higher temperature. Thus a given amount of moisture may result in a relative humidity of 100 at one temperature, but only produce a relative humidity of 75 at a higher temperature. When reference is made to a damp or dry atmosphere, it is the relative humidity and not the actual amount of moisture in the air that must be considered. For instance, the warmer air mentioned above with a relative humidity of 75 would dry clothes on washing day, but the cooler air with a relative humidity of 100 would not, because it is already saturated. (And yet, it must be noted, in these two examples it has been assumed that the actual amount of water vapour present is the same.) Not only is warm air capable of holding more moisture than cold air (a cubic foot of dry air in the Sahara may contain more moisture than a similar volume of damp air in this country), but the cooling of saturated air from 90° F. to 80° F. (ten degrees) produces a much heavier rainfall than the cooling of saturated air from 50° F. to 40° F. (also ten degrees).

This can be understood by reference to Fig. 97, which shows the curve of saturation of air by water vapour. The horizontal axis shows temperature, and the vertical axis the amount of moisture it takes to saturate air at the given temperature. The amounts of rainfall deposited by cooling from 90° to 80° and from 50° to 40° correspond to the thick vertical lines AB and CD. This principle is important because it helps to explain the torrential downpours of inter-tropical

lands, and why it is that the precipitation (rainfall, snow, and hail) of polar areas and high mountains is low, for winds which contain little moisture to begin with cannot produce heavy rainfall however much they may be cooled.

The cooling of air resulting in precipitation of rain, snow, or hail may be due to (*a*) relief; (*b*) convection; (*c*) cyclones or depressions.

(*a*) Relief.—Temperature decreases as one ascends. If, then, a wind blowing from the sea is saturated with water vapour, and comes to a high mountain range, it is forced to rise and so reaches colder layers of air. The moisture in the air is condensed and falls as rain. Mountainous districts, then, are usually wet, *e.g.* Snowdon has an annual rainfall of about 200 in., while the plains at its foot have only 30 to 40 in. Even low hills in relatively dry areas will have more rain than the surrounding plains. The North and South Downs, for example, have just over 30 in., while the plains on either side have just under 30 in. This can be seen on a rainfall map of the British Isles.

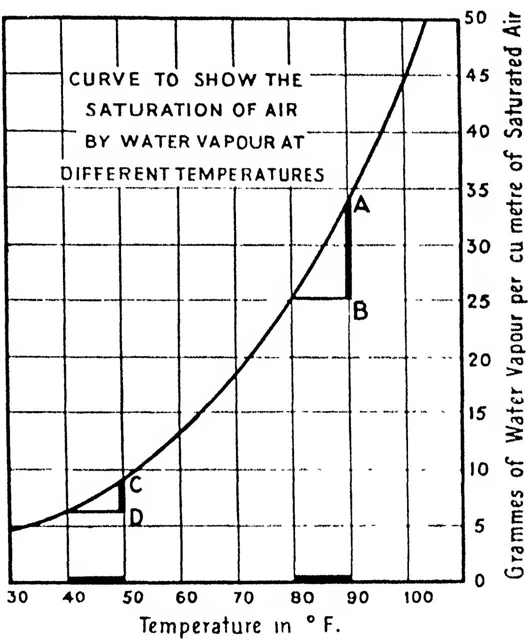


Fig. 97.

(*b*) Convection.—Hot air naturally tends to rise. As it rises it is cooled and rain falls, even though there are no mountains near. Since the air at the equator is always hot it is continuously rising, and rain falls almost every day. In summer, the interior of the northern continents also develop high temperatures, and the rainfall of these regions is therefore

mainly summer rain of the convectional type. Thunderstorm rain is also due to convection or uprising currents of overheated air. In England 76 per cent. of the thunderstorms occur in June, July, and August, 30 per cent. being in July, *i.e.* thunderstorms are most frequent in the hottest months. Large urban areas with their absence of vegetation, large expanses of bare brick and stone, tar macadamised roads, and factories, etc., seem to accumulate heat so that thunderstorm frequency is greater in places like Birmingham, Manchester, and London than it is in rural areas.

(*c*) CYCLONES OR DEPRESSIONS.—In the westerly wind belt of the temperate zone there are " breaks " in the general distribution of pressure and winds. These are cyclones and anticyclones, the former being the " depressions " of the Weather Reports and associated with rain, while the latter are associated with fine weather conditions.

Depressions are large areas of Low Pressure which approach Britain from the Atlantic, and which bring rainy and stormy weather. They are due to the meeting of streams of warm equatorial air and cold polar air. The warm air being lighter tends to rise over the heavier cold air, and condensation takes place resulting in rain. Since these depressions cross the ocean, rain falls heavily between America and the British Isles, and here again it is well to note that mountains are in no way responsible for the rainfall over the ocean.

In England the mercury in the barometer falls as a " depression " approaches; hence the falling barometer is a sign of rainy weather. Cyclones are roughly oval in shape, and may be nearly 1000 miles from end to end. There is low pressure in the centre and high pressure round the edges. The winds blow inwards to the low pressure centre.

Anticyclones are areas of High Pressure, associated with spells of fine weather, hot in summer, and clear, frosty weather in winter. As an anticyclone approaches, the barometer rises, hence, in England, a rising barometer is a sign of fine weather. The high pressure of an anticyclone is surrounded by low pressure, and winds blow outwards from the central high pressure. Figs. 98 and 99 show a typical depression and a typical anticyclone. Other examples may be studied in the daily newspapers.

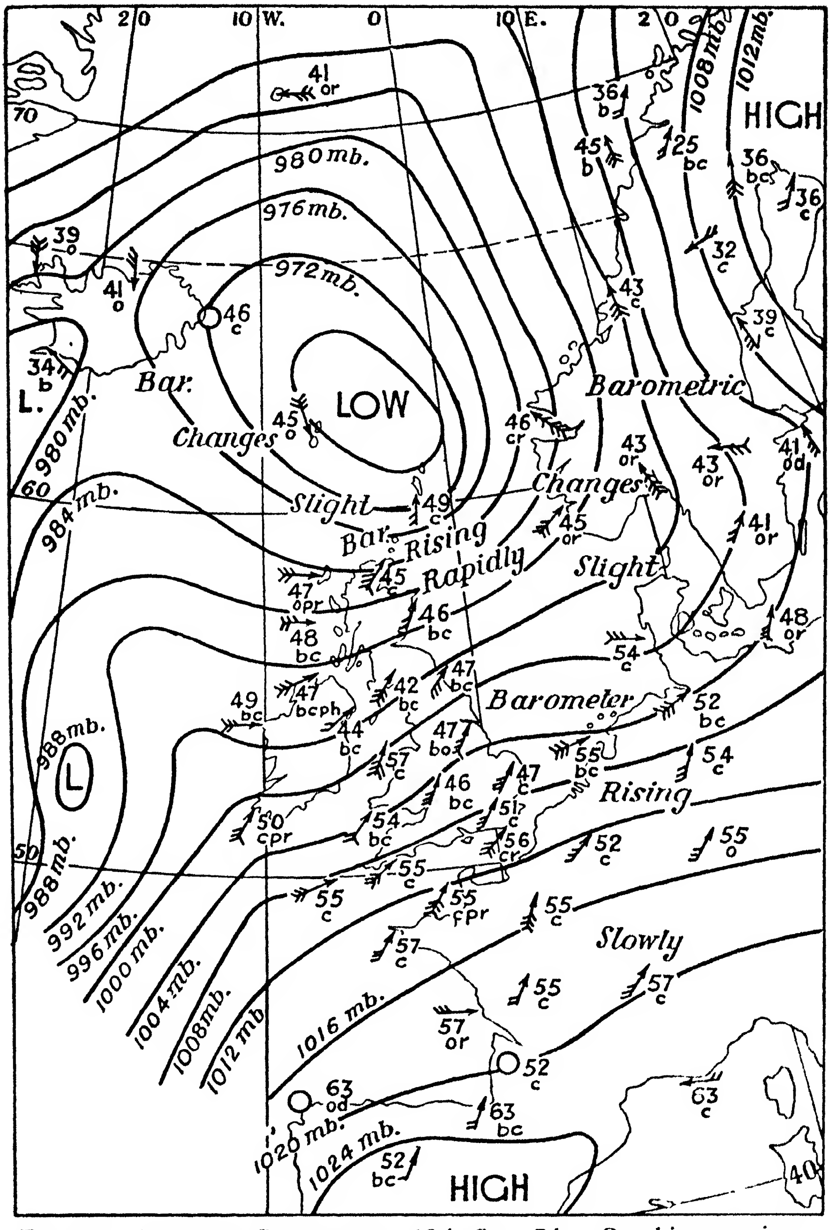


Fig. 98. Cyclonic Conditions.—19th Oct., 7 h. On this occasion a depression was developing over the Atlantic. In Eastern England and Eastern Scotland strong winds from the south were expected, with cloud followed by rain. Similar conditions, with gales, were anticipated in western districts. Rain would occur in Ireland followed by showers and bright intervals, with cooler weather later. These conditions are typical of cyclonic weather.

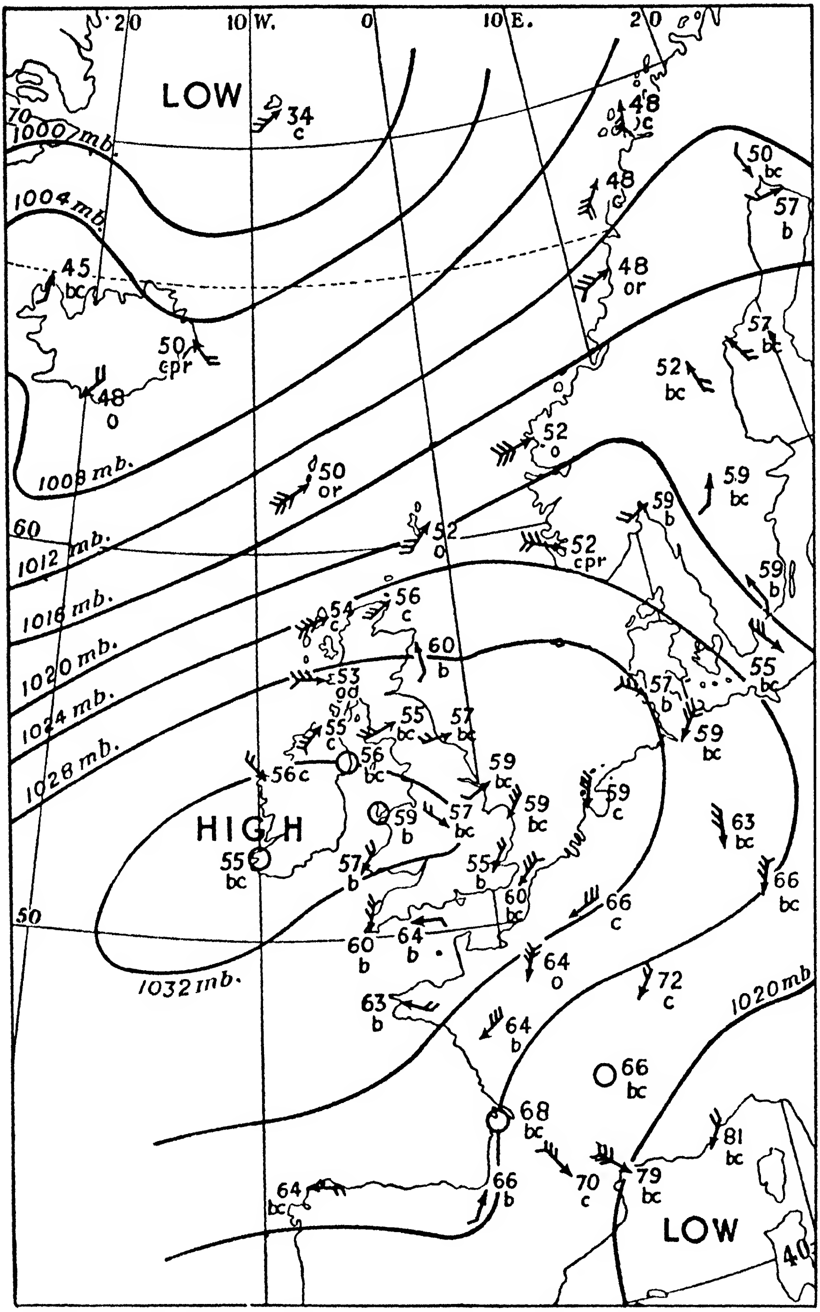


Fig. 99. Anticyclonic Conditions.—17th July, 7 h. On this occasion the forecast was several days' fine weather.

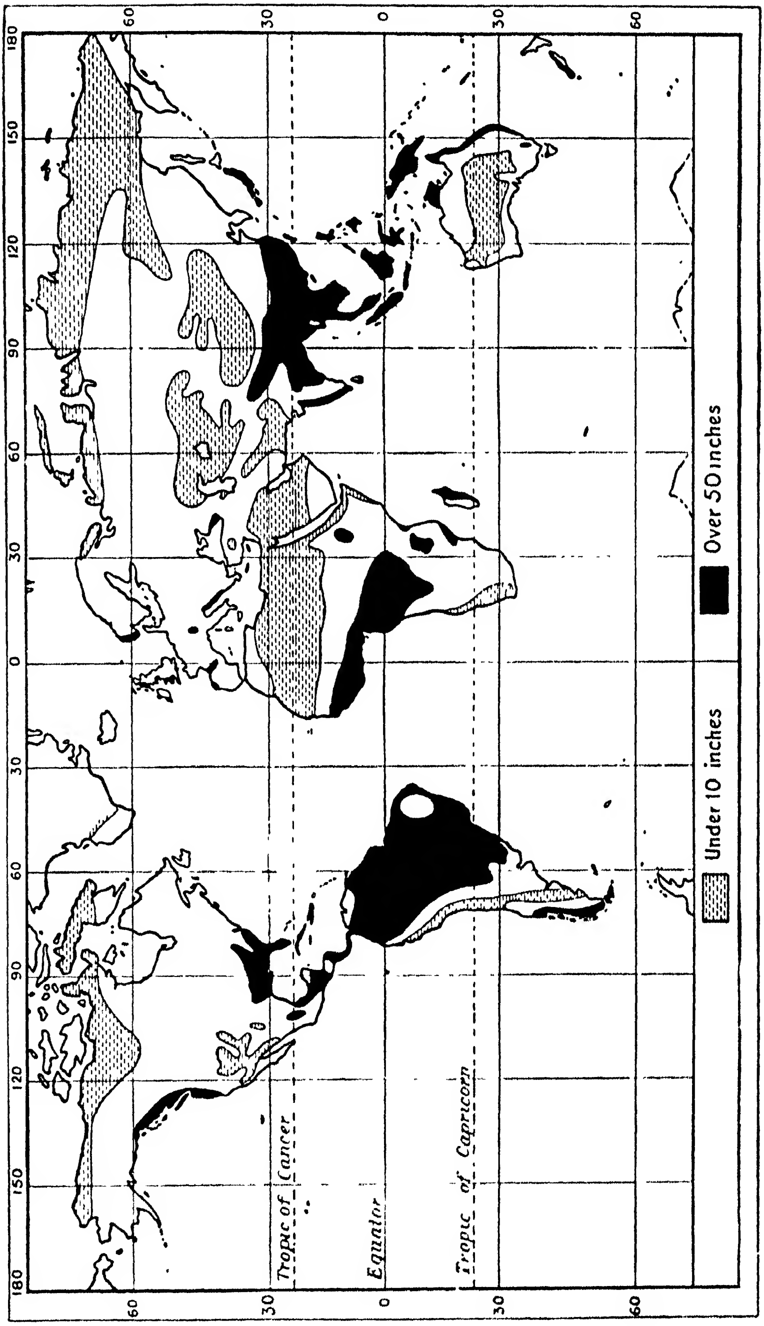


Fig. 100. The Areas of Heavy Rainfall (Over 50 in. Annually) and Scanty Rainfall (Under 10 in. Annually).

While rainfall may be due to any of the foregoing causes, the actual amount of rain that falls in a given place is due to a number of other factors.

Coastal lands generally have more rainfall than the interiors of continents. If the prevailing winds are from the sea there will be heavier rainfall than if they are from the land. The westerly winds of cool temperate lands are more likely to deposit rainfall than the Trade Winds of lower latitudes (see page 190). Mountainous areas will generally have more rain than the surrounding lowlands, and the windward side of mountains heavier rainfall than the leeward side. Ocean currents may cause either increased or decreased rainfall. When sea winds pass over a warm current they pick up more water vapour, and so the rainfall of the coastal lands is increased, viz. S.E. United States, but when on-shore winds first cross a cold current they pick up less moisture, and so drop less rain on the neighbouring coasts. This influence of cold currents is well marked in S. America (desert of N. Chile and Peru) and in S. Africa (Namib Desert).

CHAPTER XI

CLIMATIC FACTORS—III. PRESSURE AND WINDS

Measurement of Pressure

The weight or pressure of the atmosphere is measured by means of a barometer. At sea-level the mercury in a barometer measures about 30 in. (760 mm.). On modern weather maps the unit taken is 1 bar, which is divided into 1000 millibars. 1 bar is equivalent to a barometer reading of 29·53 in. The barometer (at sea-level) rarely falls below 28 in. (950 millibars) or rises above 31 in. (1050 millibars).

Pressure readings are taken daily at specified times, and the average found over a number of years, as in the case of temperature. Pressure maps are constructed by joining all places of the same air pressure. An *isobar* is a line joining all places of the same pressure at the same time (see Figs. 98 and 99). The term "high pressure" is used to denote the state of the atmosphere when the barometer reads about 30 in. or over, and the term "low pressure" is used when the reading is about 29 in. or less.

During the ascent of a mountain the mercury in the barometer falls, for not only is there less air above, but the air is becoming less dense. At a height of 18,000 ft. or about 3½ miles, the barometer would only read 15 in. (500 millibars), because half the atmosphere, by weight, is below this level and the other half above. This does not mean that the thickness of the atmosphere is seven miles, because the air becomes less and less dense away from the earth. There are probably traces of air at a height of 200 miles, but the knowledge of the stratosphere is incomplete, and man has, as yet, only ascended to a height of 13·7 miles (Fig. 101).

Planetary Winds

Although at any place pressure varies from day to day, the general distribution of air pressure over the world as a whole follows a general plan. The hottest part of the earth is always somewhere near the equator. Thus the air in these regions is heated more than elsewhere. Hot air always rises, and so

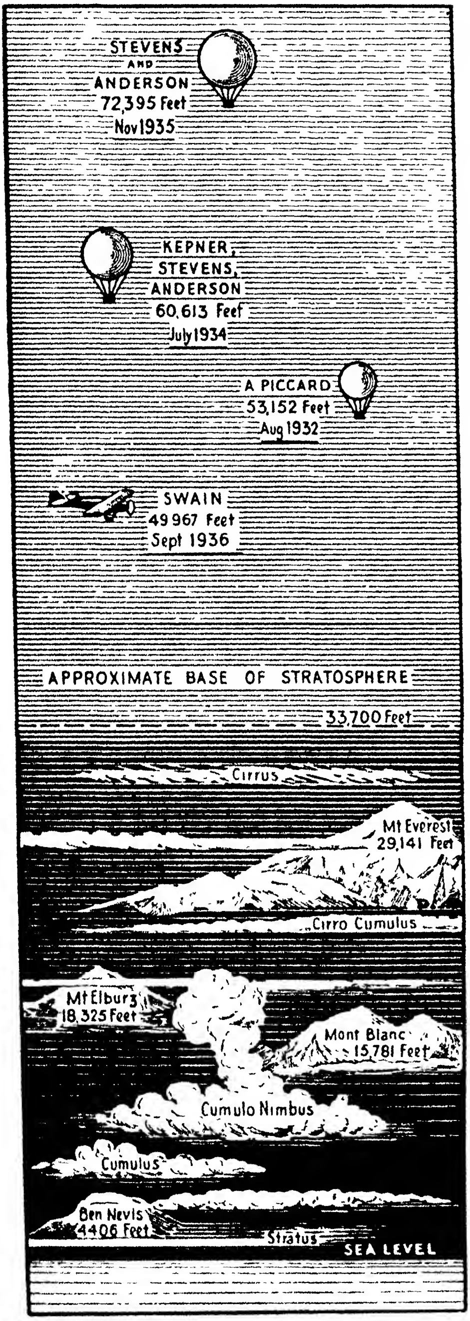


Fig. 101. Heights reached by man compared with those of mountains and clouds.

the air at A (Fig. 102) rises in the direction AB. Currents of air move towards the equator from the north and south to take the place of the rising air, and this air is, in turn, heated and forced to rise. The rising air, in time, cools, and moving N. and S. in the direction shown by the arrows, gradually sinks to the earth at C and D (about 30° N. and 30° S.), whence some of it proceeds polewards and some equator-wards, as shown in the diagram.

These currents of air are termed *convection currents.* The streams of air moving along the earth's surface are winds, and so we can see that, on a globe composed uniformly of land and water, four winds would result, as shown by dotted lines in the diagram. Owing, however, to the rotation of the earth, these winds are deflected to the right in the northern hemisphere and to the left in the southern hemisphere. (To realise which is left and right you must stand facing the direction towards which the winds are

blowing.) As a result of this deflection the planetary winds assume the direction shown by the arrows in Fig. 103.

Where the air rises at the equator the pressure of the atmosphere is low. This is a region of calms called the Doldrums. Where the air is descending and heavy, the pressure is high. These regions of high pressure are called the Horse Latitudes. Winds always blow from high pressure to low pressure. The two sets of winds blowing towards the equator from the north and south are called the N.E. and S.E. Trade Winds (not because they help "trade," but because they blow persistently over a "trodden" path). The winds blowing polewards from the high pressure belts

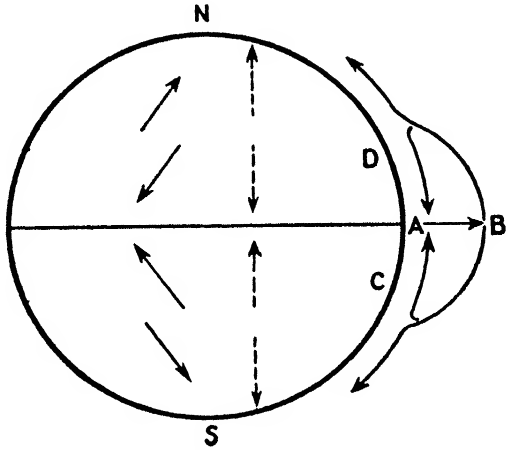


Fig. 102.

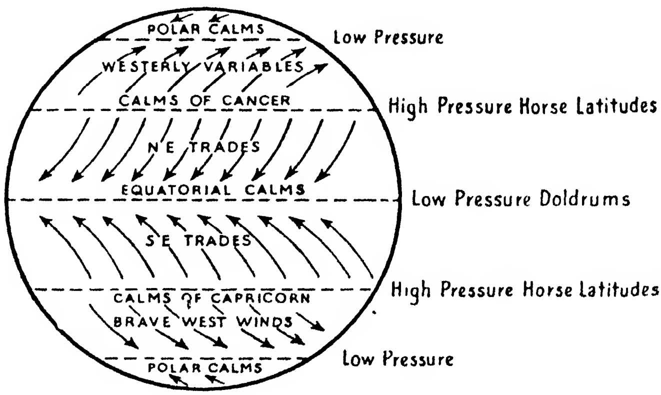


Fig. 103. PERMANENT WINDS AND CURRENTS.

are known as Westerly Variables, mainly S.W. in the northern hemisphere and N.W. in the southern hemisphere. In the south temperate zone there is so little land that the

westerly winds blow without interruption and with great force. The latitudes 40° S. to 50° S. are, on this account, known as the Roaring Forties, and those in latitudes 50° to 60° as the Furious Fifties.

Unfortunately, this relatively simple plan of world pressure and winds is broken as a result of the unequal heating and cooling of land and water.

Land and Sea Breezes

During the day the land becomes hotter than the sea, and the air over the land rises. During calm hot weather a cool current of air moves in from the sea to take the place of the rising air over the land. This is a sea breeze which mainly blows during the daytime. At night, however, the land cools

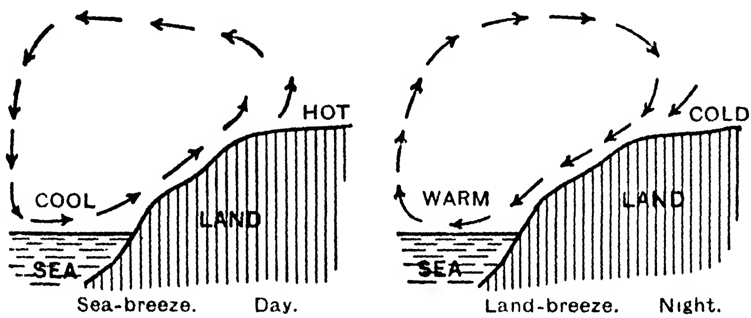


Fig. 104.

quickly so that it is colder than the sea, and the air stream (in calm, cloudless weather) is reversed, producing a land wind blowing out to sea. These breezes may be observed at English seaside resorts during spells of calm, fine weather. They are also well marked around the coastline of the Eastern Mediterranean.

Monsoons

Monsoons may be regarded as land and sea breezes on a continental scale. The word " monsoon " is derived from an Arabic word meaning " season." Instead of winds varying from day to day, they vary from season to season, *i.e.* from summer to winter; the winds blowing from sea to land in summer and land to sea in winter.

The monsoon system is associated with the lands of South-East Asia, Eastern Africa, and Northern Australia. The conditions which appear to be necessary for monsoons are:—

(*a*) A land mass of considerable extent.

(*b*) An almost east to west trending coastline in tropical or warm temperate latitudes.

(*c*) An extensive ocean on the equatorial side of the land mass.

In *summer* the land is hotter than the sea, there is therefore low pressure over the land and high pressure over the sea. The winds blow from high to low pressure, *i.e.* from the sea to the land, and are therefore wet winds.

In *winter* the conditions are reversed. The land is colder than the sea, so that there is high pressure over the land and low pressure over the sea. The winds blow from high to low pressure, *i.e.* from land to sea, and are therefore dry winds. The above is a simple explanation of the principle underlying monsoons, but in Asia there are really two monsoon systems. The first has its centre of origin in Central Asia, north of the Himalayas, and the second in N.W. India.

(1) The most widespread monsoon system of Asia is that which affects all South-East Asia except India, viz. Indo-China, China, and Japan. Its centre of origin is Central Asia. During the summer, winds are drawn in to the low pressure area of Central Asia and blow as south-westerly winds in Siam, southerly and south-easterly winds in China, and as easterly winds in Japan and Manchukuo. These wet in-blowing winds deposit rain over all the lands of South-East Asia (except India), and, in general, the amount of rain decreases from South China northwards.

In winter the monsoon blows from the land, and is a very strong and bitterly cold wind. In Siam it is north-easterly, in China northerly and north-westerly, and in Japan and Manchukuo easterly.

(2) The Indian monsoon is quite distinct from the general monsoon of the remainder of south-east Asia. The Himalayas are so high that they project into the stratosphere (above the level of the usual planetary winds), and so they

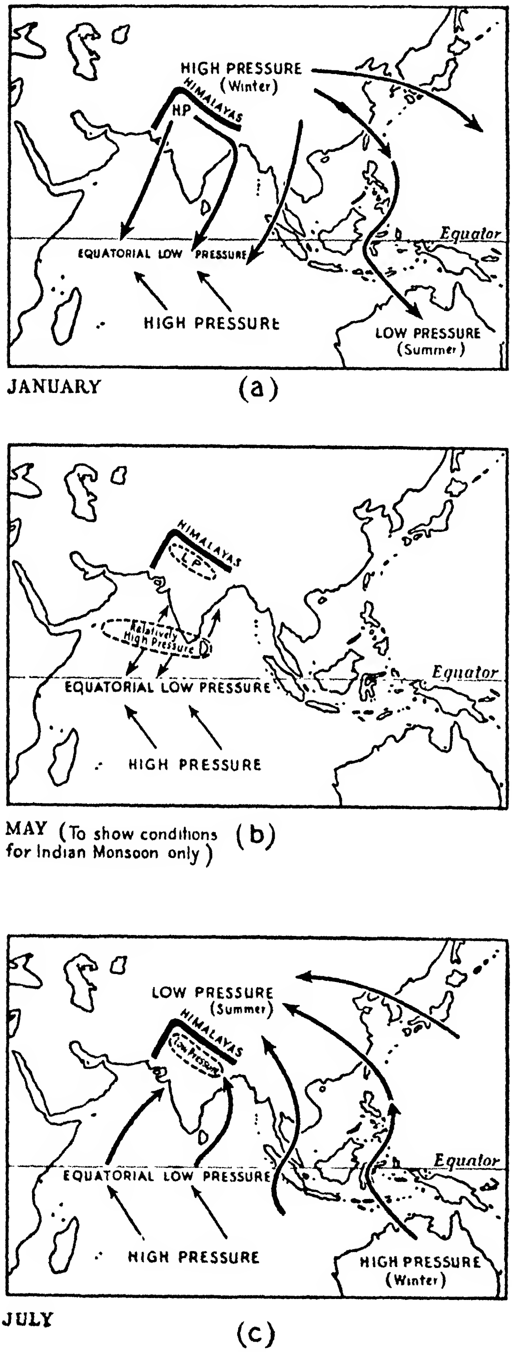


Fig. 105. THE WINDS OF THE MONSOON AREAS.

form an effective meteorological barrier between India and Central Asia.

In January [Fig. 105(*a*)] a weak high pressure system develops over the Punjab (N.W. India) and from this the Indian winter monsoon originates. The north-east winter monsoon is a gentle wind blowing 3 or 4 miles an hour, and it is not bitterly cold, as it would be if it originated to the north of the Himalayas.

In May [Fig. 105(*b*)] low pressure conditions are developing over Northern India, but in the latitudes of the South Deccan high pressure still persists, forming a meteorological barrier between the low pressure at the equator and the low pressure of the Punjab. The light south-west winds which commence to blow bring rains to the S.W. Ghats, especially in the

neighbourhood of Calicut, where they are known as " Mango " showers.

In June [Fig. 105(*c*)] the high pressure over the Deccan has disappeared because of the rising temperature, and the low pressure of the Punjab has become more intense. The disappearance of the high pressure barrier in Southern India marks the " breaking " of the monsoon. The winds from the sea (the south-west Monsoon) blow uninterruptedly northwards to the Punjab " Low," and cause heavy rain over most of India. Even in Southern India there is a marked change from the light mango showers to the torrential rains of the monsoon. During the rainy season the heaviest rainfall occurs along the west coast and in the lower Ganges valley.

(3) The monsoon system of North Australia is closely associated with the Indian monsoon. In January the dry out-blowing winter winds from Asia sweep southwards across the Equator and reach Northern Australia after crossing a vast expanse of ocean. They reach Northern Australia as wet north-west winds, during the summer months of the southern hemisphere. In July the conditions are reversed. Northern Australia, experiencing winter conditions, has a dry, out-blowing south-easterly wind, which blows northward across the Indian Ocean, and reaches Asia as the wet south-west or south-east summer monsoon.

CHAPTER XII

NATURAL REGIONS

Introductory

In Chapter II. reference was made to the migration of the overhead sun between the tropics according to the seasons, and in Chapter XI. the planetary system was described. But the arrangement of winds depicted in Fig. 103 refers only to the equinoxes, when the sun is overhead at the equator and the region of maximum heat is almost coincident with that line.

As the overhead sun migrates north and south between the tropics it is followed by the belts of greatest heat (Fig. 106), and consequently by the belts of lowest pressure in which the planetary wind system originates. The consequent north and south migration of the whole of the planetary winds is known as " the Swing of the Wind System."

The Swing of the Wind System

In July the sun is overhead north of the equator, and the hottest area lies north of the equator at B [Fig. 107(*b*).] This means that the area where the hot air rises is north of the equator, with the result that the whole wind system is farther north than at the equinoxes.

In January, the sun is overhead south of the equator, the heat belt is south of the equator at C [Fig. 107(*a*)], and as a result the whole of the wind system is further south than at the equinoxes. This north and south movement of the equatorial heat belt has very important consequences, for, as a result of this " swing," certain places do not have the same wind at all seasons of the year, as would be the case if the wind belts remained constant. The results are most marked on the western sides of continents.

South-westerly winds in the northern hemisphere and *north-westerly* winds in the southern hemisphere are blowing polewards, and therefore becoming cooler. Thus they are losing their capacity for holding moisture, and tend to drop rain. We can consider them to be mainly wet winds when they blow from the ocean to the west coasts of continents.

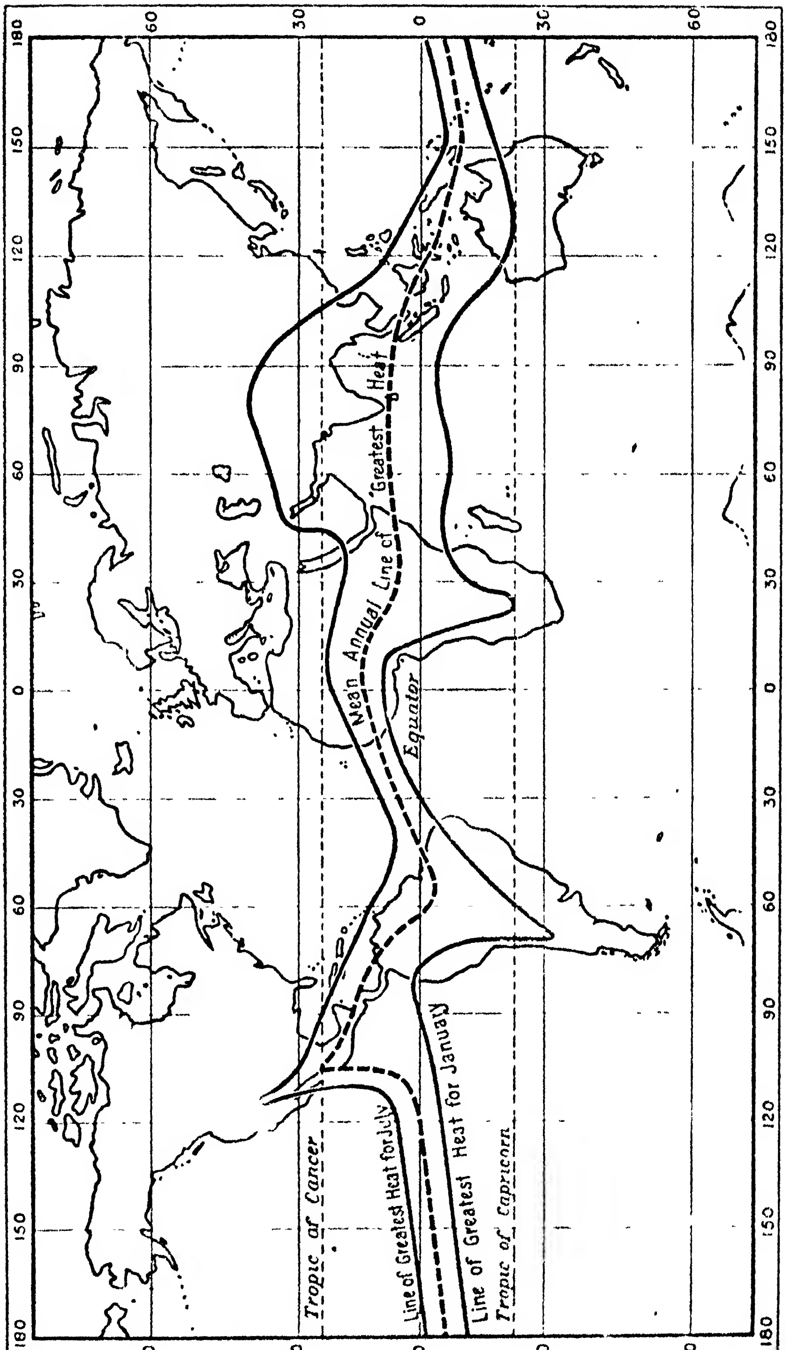


Fig. 106. The Heat Equators.

Trade Winds are blowing equator-wards and becoming hotter. Thus they increase their capacity for holding moisture, and tend to pick up moisture rather than to drop rain. These can, therefore, be considered as drying winds, bringing with them fine weather and low rainfall, except where they meet high mountains (*e.g.* in British Guiana).

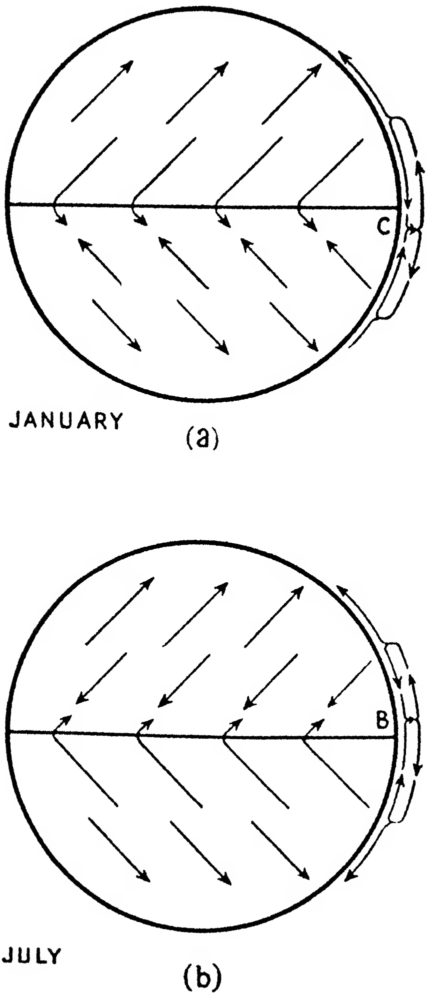


Fig. 107. Diagram to Show the Migration of Wind Belts North and South of the Equator.

High pressure areas, like anticyclones, are regions of fine, dry weather.

Low pressure areas, such as the Doldrums around the equator, are regions of rising and cooling air and heavy rain.

In Fig. 108 the unbroken lines denote the wet Westerlies; the broken lines are the drying Trade Winds, and the low pressure areas are rainy regions. You will notice that the July winds are drawn further north than the January winds, because of the " Swing of the Wind System." The belt indicated by C has westerlies during the winter, so that the winters are wet; and trades during the summers, so that the summers are dry. This region of wet winters and dry summers is known as a " Mediterranean region," because it is the typical climate of lands bordering the Mediterranean Sea. This type of climate does not extend across the centre and east

of a continent because the westerlies are no longer rain-bearing after they have crossed large stretches of land. Thus Fig. 108 refers only to the western margins of continents. The other west coast belts can be worked out from the diagram,

		1 July (Summer)	2 Jan. (Winter)	3 Winds	4 Rainfall	5 Type
NORTHERN HEMISPHERE	A			Stronger westerlies in summer than winter	Light summer rain	Tundra
	B			Westerlies in winter Westerlies in summer	Wet winters Wet summers	British
	C			Westerlies in winter Trades in summer	Wet winters Dry summers	Mediter-ranean
	D			Trades in winter Trades in summer	Dry winters Dry summers	Desert
	E	Low Pressure		Trades in winter L.P. in summer	Dry winters Wet summers	Savana
	F	Low Pressure	Low Pressure	L.P. in summer L.P. in winter	Rain all year	Equa-torial
SOUTHERN HEMISPHERE	E		Low Pressure	Trades in winter L.P. in summer	Dry winters Wet summers	Savana
	D			Trades in winter Trades in summer	Dry winters Dry summers	Desert
	C			Westerlies in winter Trades in summer	Wet winters Dry summers	Mediter-ranean
	B			Westerlies in winter Westerlies in summer	Wet winters Wet summers	British
	A			Stronger westerlies in summer than winter	Light summer rain	Tundra
		July (Winter)	Jan. (Summer)			

Fig. 108.

CLIMATES ON THE WESTERN MARGINS OF CONTINENTS.

and it must be noted that the sequence of climate is the same from the equator northwards and southwards, and that regions with similar climates occur in approximately the same latitudes north and south of the equator.

Natural Regions

The types named in column 5 are some of the divisions of the world that are termed "natural regions." *A natural region is one throughout which the conditions of relief, temperature, rainfall, natural and cultivated vegetation, and consequently human activities are almost uniform.*

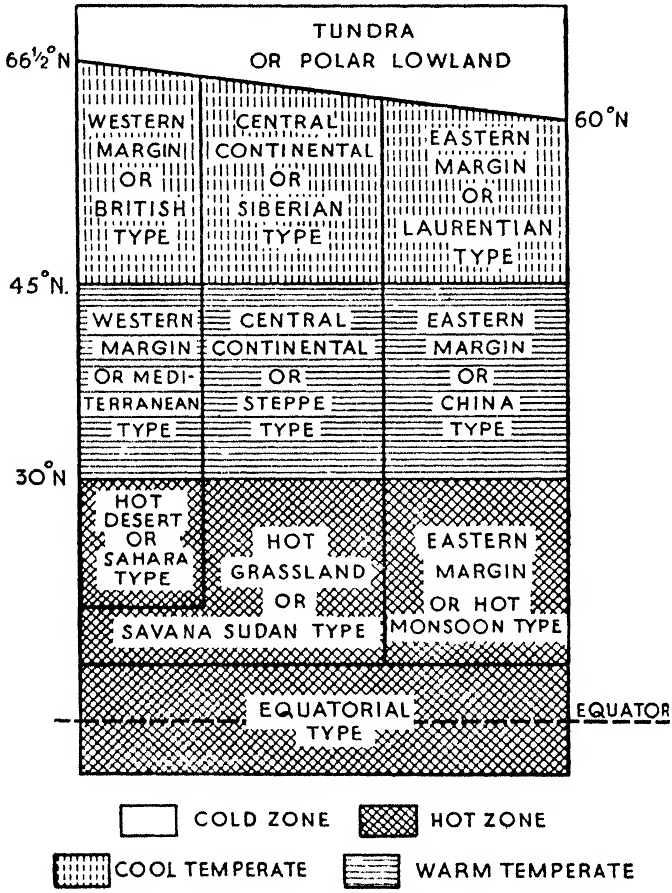


Fig. 109. Simple Scheme of Natural Regions.

In the following pages a very simple scheme for dividing the world into natural regions is outlined. At first no allowance will be made for mountain masses, which, because of their altitude, have climates differing from those of the surrounding plains both in temperature and rainfall.

When, however, the simple scheme has been mastered, mountains must be taken as a special group of natural regions, varying with latitude, and, since they act as wind barriers and rain divides, these mountainous areas will be the dividing zones between other natural regions. For example, the Rockies of Canada divide the equable climate of British Columbia from the continental climate of Central Canada. The Rockies, however, are not a single mountain chain, but a wide mountain mass, and have a distinct climate of their own.

Examine Fig. 109. Suppose that the rectangle represents a continent lying mainly north of the equator.

Firstly, divide it into four zones according to latitude, viz. (1) the cold zone north of the Arctic Circle; (2) the cool temperate zone from latitude 45° N. to the Arctic Circle; (3) the warm temperate zone from latitudes 30° N. to 45° N.; (4) the hot zone between the equator and 30° N. Then divide each of the temperate belts into three sections so as to give a western, central, and eastern area in each belt. In the hot zone, cut off a strip for the equatorial area, and then again divide the remainder into three sections, noting carefully that on the west coast the desert area does not touch the equatorial area.

The same principles of subdivision can be applied to the southern continents, but it must be remembered that their narrowness does not always allow subdivision into three sections, the central section being crowded out. For instance, in the cool temperate zone of South America there is no central section with a climate similar to that of Central Canada.

The value of studying the world from the point of view of natural regions has many advantages. If the natural conditions (rainfall, temperature, vegetation, etc.), of the British type are known for Europe, then they have only to be applied to the cool temperate western margins of any other continent, for they will be similar for any other region of the same type.

Fig. 110 is a simple rainfall diagram based on the same division of a continent into natural regions. It shows both the seasons in which rain falls and the season of maximum rainfall. In the case of summer rain areas the closeness of the shading shows that Monsoon areas have more rain than Savana areas, and Savana areas have more than Steppe and Siberian regions.

The Rainfall of the Major Natural Regions

At this point it may be useful to classify some of the main rainfall regions of the world.

A. RAIN ALL THE YEAR.—The regions which have rain all the year round may be classified as follows:—

(1) *The western margins of continents in the cool temperate belt.* Here the rainfall is brought by the prevailing westerlies, and is either relief rain or cyclonic rain. The maximum

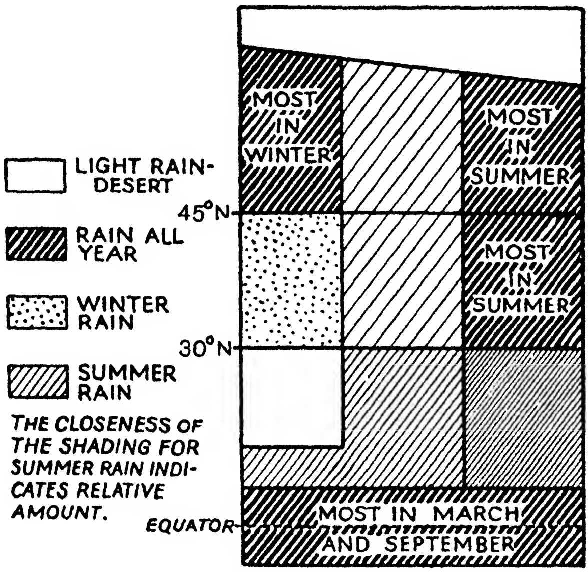


Fig. 110. RAINFALL.

rainfall occurs in winter, and except on lee side of mountain masses it is large in amount, *e.g.* Snowdon has 200 inches annually.

(2) *Equatorial lowland areas.* These areas include the districts where the rainfall is heavy and of the convectional type. Maxima occur just after the period of the overhead sun (the equinoxes).

(3) *The eastern margins of continents in both cool and warm temperate latitudes.* The rainfall is mainly monsoonal in Asia but in N. America is also due to the passage of depressions. The amount varies, being lighter in the higher, and heavier in the lower, latitudes. The maximum rainfall is in summer.

B. Summer Rain.—In the three following regions, rain occurs only in the summer months.

(1) *Continental interiors of the cool and warm temperate zones.* The rainfall is light (20 in.) and is mainly convectional in type.

(2) *The Savana regions N. and S. of the equatorial areas.* The rainfall is convectional, and is due to the N. and S. migration of the equatorial low pressure belt. It varies in amount from 10 in. on the desert edge to 60 in. on the equatorial forest borders.

(3) *Monsoon lands.* In these regions the rainfall is due to in-blowing summer monsoons, and varies greatly in amount. The heaviest recorded rainfall is at Cherrapunji in the Assam Hills, with a mean annual rainfall of 458 in., though as much as 905 in. has been recorded in one year (and 40 in. in a single day). Some parts of the monsoon lands have light or scanty rainfall. The rainfall of the Deccan is less than 40 in., and that of the Thar Desert in N.W. India is less than 10 in.

C. Scanty Rainfall.—There are two types of regions where rainfall is scanty. They are:—

(1) *The polar lowland.* In these areas the rainfall is less than 10 in. The maximum occurs in summer, and winter precipitation is usually in the form of snow.

(2) *Hot deserts on the western margins of land masses in the hot zone.* The rainfall is again less than 10 in., but the period of maximum rainfall varies, *e.g.* in the north of the Sahara near to the Mediterranean the maximum tends to occur in winter, but on the south side of the Sahara, near to the Savana regions, the maximum is in summer.

D. Regions of Winter Rain.—The only examples are to be found on the western margins of continents in the warm temperate zone, viz. " Mediterranean " areas. The rainfall is moderate (20 in.-30 in.), and the bulk of it falls during the winter months. At least one or two (and often more) summer months are virtually rainless, and near the desert borders, *i.e.* in North Africa, there may be seven months with a rainfall of less than one inch.

The Vegetation of the Major Natural Regions

Fig. 111 shows the characteristic vegetation of the natural regions. Remember that in many areas the natural forest has been cleared and crops are grown, while much of the grassland has also been cultivated.

The natural vegetation of the world may be divided into forests, grasslands, deserts. These in turn may be subdivided.

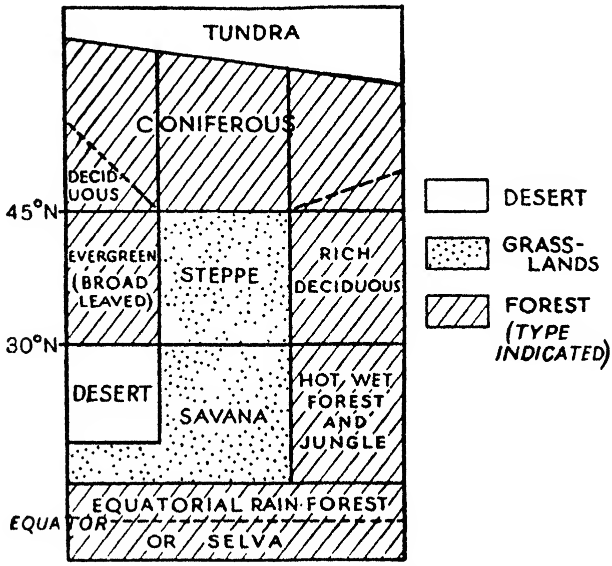


Fig. 111. VEGETATION.

(*a*) FORESTS.—(1) *Cool Temperate.* Coniferous; deciduous.
(2) *Warm Temperate.* Richer deciduous; broad-leaved evergreens.
(3) *Hot.* Monsoon; equatorial.

(*b*) GRASSLANDS.—(1) *Warm zone.* Steppe—these extend into the cool zone where there is deficient rainfall.
(2) *Hot zone.* Savanas.

(*c*) DESERTS.—(1) *Cold.* Tundra.
(2) *Hot.* Trade Wind Deserts.

The vegetation of a region varies according to the temperature, rainfall, and soil conditions. A number of factors are necessary for the growth of vegetation, but the two most

important are warmth and moisture. Warmth varies mainly with latitude, but the amount of moisture available for plant growth cannot be judged absolutely by a mere consideration of the rain that falls in a given region. Some of the rain runs off the surface to feed rivulets and streams, and some is evaporated and the remainder percolates into the ground. It is the amount available in the surface layers of the ground that helps to determine the characteristic vegetation of a region. This is well seen in the prairies where cotton trees line the streams of these " treeless " areas. If a region has very high summer temperatures much of the rain is evaporated, leaving relatively little for plant life. Again, since the roots of plants absorb their food in solution, it follows that they must become inactive during any period when the ground is frozen; more than that, most plants cannot obtain plant foods from the ground when the temperature falls below about 41° F. Thus a period of intense cold is, as far as plant life is concerned, equivalent to a period of drought, since neither during drought nor cold can plants absorb plant foods in solution.

Therefore we find that while 20 in. of rain will support trees in the continental interiors of the *cool* temperate zone, the same amount of rainfall in the continental interiors of the warm temperate zone will only support grass (steppe lands). This is because of the increased summer temperatures and the consequent increase in evaporation.

In the hot lands 60 in. of rain is necessary for permanent forest. Where the rainfall is below 60 in. the forest gives way to " park lands," *i.e.* grass lands interspersed with groves of trees, and as the rainfall still further decreases, to open grass land, and finally to scrub.

Plants have to adapt themselves to withstand drought, whether it be the drought of scanty rainfall, or the " pseudo drought " which results from low temperatures. Thus deciduous trees shed their leaves during the cold season. In the British type of climate this is a wet season, but the low temperatures limit growth. In other areas of deciduous forest (see Fig. 111) leaves are also shed in the " cold " season, but in these regions the cold season is also the drier season.

Conifers combat the cold by reducing the size of their leaves.

All conifers have needle-shaped leaves which they retain throughout the year.

The broad-leaved evergreens of the "Mediterranean" areas should, if they followed the laws of nature, shed their leaves during the drought of summer. As it is, these trees grow slowly during the mild wet winters, and retain their leaves throughout the summer. They take special precautions, however, against the summer drought by having relatively small hard, leathery and waxy leaves, a woody structure, deeply-penetrating roots, and various water and food-storing devices.

In the equatorial forest zone where it is always hot and wet, plants can grow freely throughout the year. There is no period of drought. This forest has the appearance of being always green, since there is no definite season when all the trees shed their leaves. Thus it is possible to see within a short distance of one another, trees in full leaf, trees quite bare, trees in flower, and trees bearing fruit.

CHAPTER XIII

NATURAL REGIONS—THE COLD LANDS

Broadly speaking, the cold lands lie within the Arctic Circle, and may be classified as (*a*) Highland or Ice Cap type, and (*b*) Lowland or Tundra (Fig. 112).

Ice Cap Type

In such regions the land is covered with a mantle of snow and ice all the year round, and are therefore useless to man. This type is found in Greenland and the Antarctic continent, and it is only on the coastal margins of Greenland that a few Eskimos have settled.

Tundra or Polar Lowland

Before the tundra regions are described in detail, the climate and vegetation of such areas must be considered.

CLIMATE.—These are treeless plains lying north of the great forest belt of the temperate zone. Trees do not grow where the summer temperature falls below 50° F., hence the southern limit of the tundra is marked by the July or summer isotherm of 50° F. A study of world isotherm maps will show that there are no land areas in the southern hemisphere, apart from the Antarctic highlands, which lie south of the summer isotherm of 50° F. In the northern hemisphere the tundra areas are:—

(1) The northern lowlands of Siberia and European Russia.

(2) The northern lowlands of Canada.

Tundra regions have short, cool summers (under 50° F.), and very cold, long winters (usually below 0° F.). The summer days are long and the winter days very short (see Chapter II.). The rainfall is light and generally less than 10 in. annually. Most of this rain falls in the summer half-year, when the westerlies are strongest in these regions. In winter, precipitation takes the form of snow, but as it is so cold the snow does not melt. This accumulation of snow

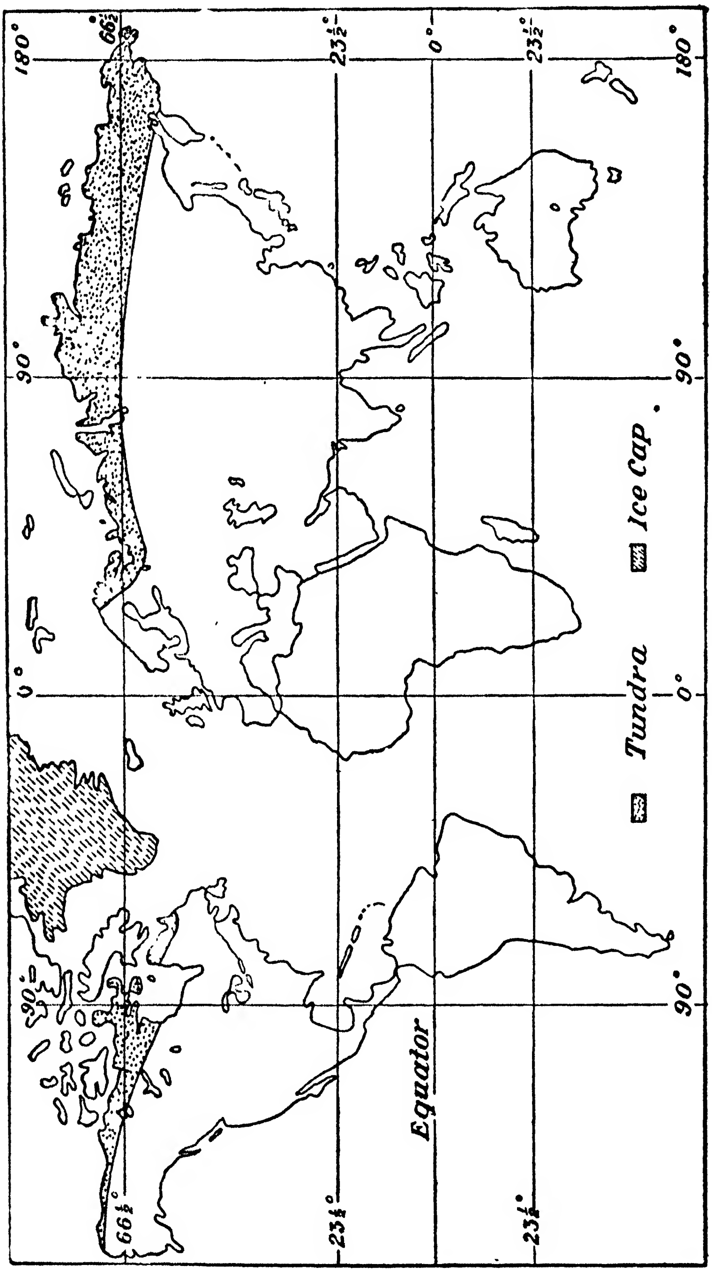


Fig. 112. COLD LANDS.

tends to give an erroneous impression of the amount of winter precipitation. Even in winter large areas have no snow covering, as a result of the strong winds which sweep the surface quite bare and pile the snow elsewhere into great drifts.

Fig. 113 illustrates the temperature and rainfall conditions of a place on the edge of the tundra. Kola is a town on the north coast of European Russia, and has been chosen because it is difficult to obtain reliable climatic records for the heart of a tundra area. As Kola is near to the moderating influences of the North Atlantic, its winter temperatures are warmer

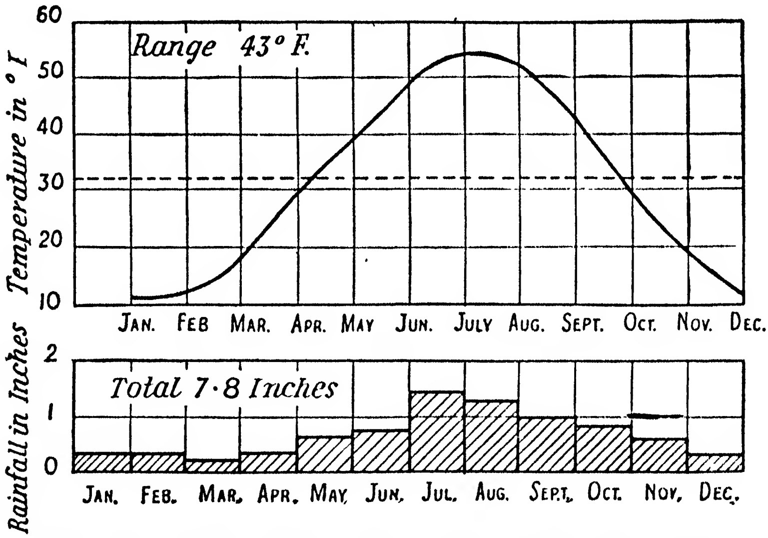


Fig. 113. TUNDRA TYPE. KOLA (33 FT. ABOVE SEA LEVEL).

than one would expect in tundra areas. The rainfall graph shows how little rainfall (or snowfall) there is during the winter months, and that the average annual rainfall is less than 10 in. Thus ,tundra areas may be classified as cold deserts, since it is customary to consider as desert lands regions with less than 10 in. of rain.

VEGETATION.—The tundra is covered for the most part with mosses and lichens, but on sunny, south-facing and well-drained slopes one finds in summer beautiful carpets of flowers, known as " bloom mats." In other localities grow short berry-bearing bushes similar to the bilberries of our

moorlands, while along the river courses may be found stunted birch trees. In these regions agriculture is impossible because of the shortness and coolness of the summers, and because the ground is frozen for more than half the year.

STAGES OF DEVELOPMENT.—The tundra lands do not show any successive stages of development, as they are almost entirely inhabited by primitive peoples.

In the tundra of North America the Eskimo depends on the hunting and fishing, and to a slight extent, on recently-introduced herds of reindeer. In contrast, the peoples of the Eurasian tundra depend mainly on their herds of reindeer, but are also engaged in hunting and fishing. Since the reindeer move from place to place in search of food, these peoples (Yakuts, Lapps, and Samoyeds) are nomadic.

CHAPTER XIV

NATURAL REGIONS—THE COOL TEMPERATE LANDS

Classification

According to the simple scheme outlined in Chapter XII., the cool temperate lands may be divided into:—

(1) Western Margin or British type.

(2) Central or Siberian type.

(3) Eastern Margin or Laurentian type.

THE COOL TEMPERATE BELT

Vegetation

The cool temperate belt lies between lat. 45° N. and the tundra areas. Except where rainfall is light, as in southern Alberta, which is sheltered from rain-bearing winds by the Rockies, the whole of the cool temperate zone is a forested area, and is shown on Fig. 111. This forest is mainly of coniferous or cone-bearing trees, *e.g.* pine, fir, spruce, and larch. But where conditions are milder and wetter, as in the plains of Europe, the trees are deciduous, *e.g.* the oak, ash, elm, beech, alder, poplar, etc.

In the deciduous forest belt, conifers are found, (1) where it is colder, *i.e.* on mountains such as the Black Forest or the slopes of the Norwegian mountains; (2) where the soils are light and sandy, as in the New Forest of Hampshire, or Delamere Forest in Cheshire. Where the rock is very porous, as on the Chalk Downs of south-east England, forests rarely grow. In Europe very little of the deciduous forest remains, as the land has been cleared for agriculture, and in Canada much of the coniferous forest has been cut down, both to supply the world's demand for timber and to make room for wheat growing and general farming.

WESTERN MARGIN OR BRITISH TYPE

Climate

Valentia, in South-West Ireland, has been taken as an example of western margin conditions. The temperature

graph (Fig. 14) shows that there is little difference (range 15° F.) between summer and winter temperatures as compared with some of the examples that will be dealt with later. The outstanding features of the climate of this region are the equability and unusual warmth of the winters for the latitude. Winters in these regions do not fall below freezing point, and in the north of Scotland, for instance, the winters are about 40 degrees warmer than the average for the latitude. The

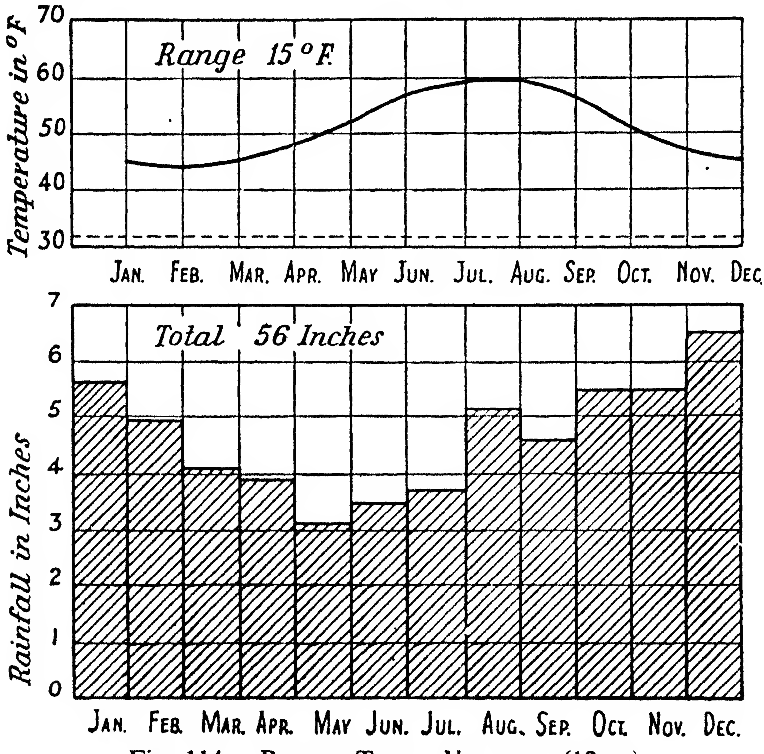


Fig. 114. BRITISH TYPE. VALENTIA (12 FT.).

mildness of the winters and the fact that the summers are not unduly hot (60° F.) is due to the prevaıent westerly winds which, coming from the ocean, raise the temperature of the land in winter, and lower the summer temperatures. The shores of these regions are washed by warm ocean currents, flowing polewards, and these also help to raise the winter temperatures.

The westerly winds are also responsible for the rainfall. They blow all the year round, and therefore rain falls in

every month, though generally there is more in winter than in summer (Fig. 114). The amount of rainfall varies. On high mountainous areas an annual fall of 200 in. may occur (*e.g.* Snowdon), while in sheltered regions the total rainfall may be as little as 20 in., as at Shoeburyness. The rainfall is increased by " depressions " which follow the track of the westerlies (see Chapter X.).

The regions of the world having this type of climate are shown and named on Fig. 115.

Development

The development of forested areas often follows this sequence: (1) hunting and trapping of animals for their furs; (2) lumbering and the manufacture of wooden articles; (3) agriculture on the cleared land; (4) manufacturing, if some form of power is available, *i.e.* coal or water power. Some of the temperate forest regions have reached the fourth stage, while others are still engaged principally in trapping or lumbering.

The whole of this region in Europe was originally covered with forests, usually of the deciduous type, except where altitude or soil conditions encouraged the growth of coniferous forest. Most of this forest has now been cleared, but there are isolated patches in some of the mountainous areas, as in the north of Spain and the Vosges Mountains, while the Scandinavian peninsula still has large areas of forest land. The clearing of the trees and the gradual spread of agriculture and settlement in the cleared lands was a slow process. To-day, the development of N.W. Europe has proceeded far beyond the primitive agricultural stage, for the discovery of minerals, and in particular coal, has led to the development of mining, industries, and commerce on a very large scale. Thus N.W. Europe is very highly developed and contains areas of extremely dense population centred mainly on the coalfields. These are principally in Great Britain, N.E. France, Belgium, the Ruhr Valley of Germany, and the Saar Basin. In N.W. Europe, agriculture is of the intensive type, *e.g.* by scientific methods the land is made to yield as great a return as possible. The other regions of this type are not yet fully developed, and in them there is as yet little industrial activity. In British Columbia lumbering is still important, but fishing,

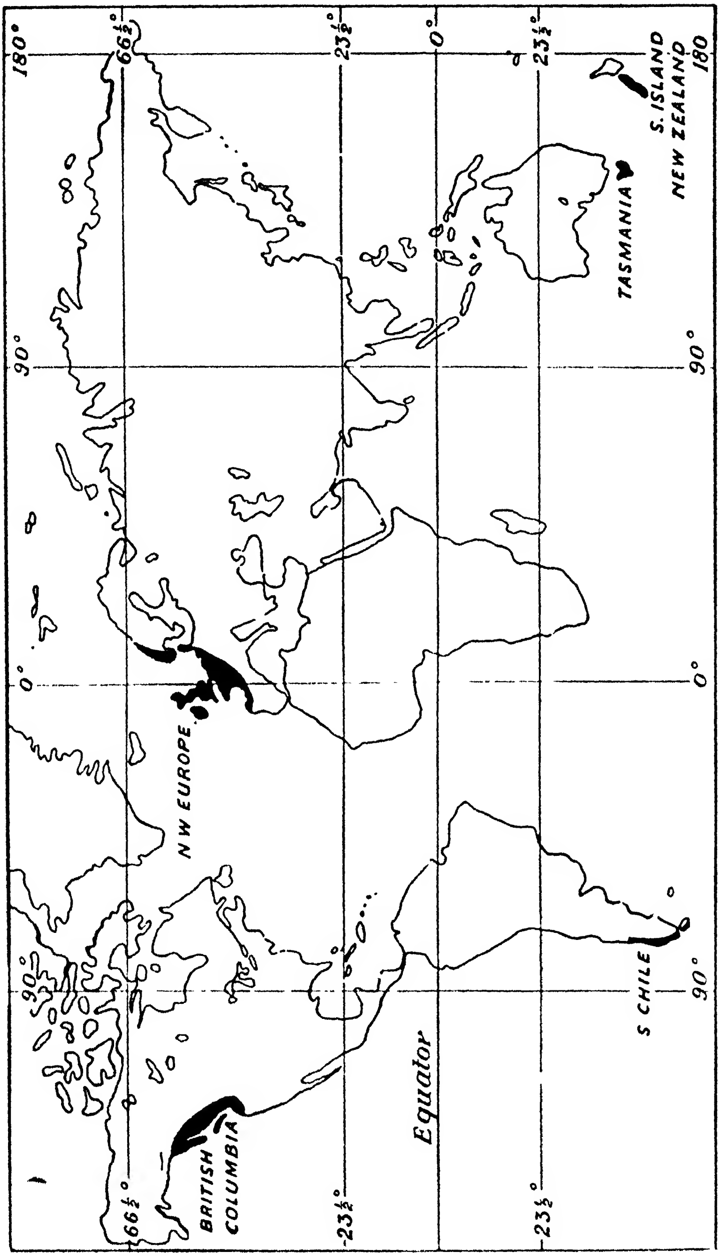


Fig. 115. Areas with British Type of Climate.

mining, and fruit growing are well developed. Tasmania and S. Island, New Zealand are mainly agricultural, but there are vast tracts of uncleared forest. The south of Chile remains undeveloped, but offers great possibilities for lumbering, fishing, and dairying.

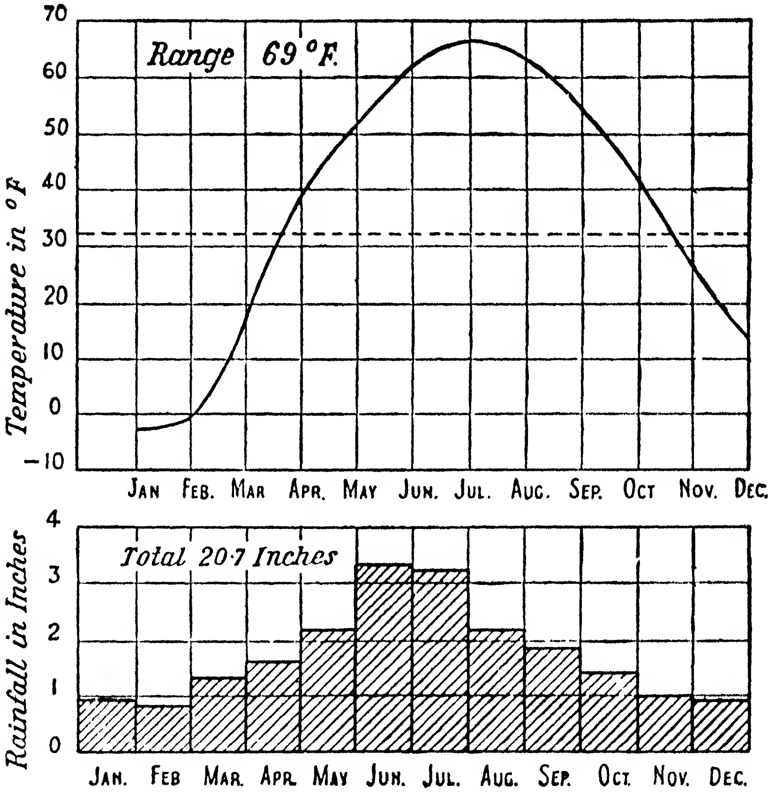


FIG. 116. SIBERIAN TYPE. WINNIPEG (1492 FT.).

COOL TEMPERATE OR SIBERIAN TYPE

Climate

The climate of this type is one of extremes as a result of the distance from the sea. The summers are hot (approaching 70° F.), and the winters very cold (often below 0° F.). The rainfall is light, averaging about 20 in., and it falls mainly in the spring and early summer. This rainfall is primarily convectional (see Chapter X.). Winnipeg has been taken as an example to illustrate the climate of this type (Fig. 116).

It is instructive to compare this temperature graph with that for Valentia (Fig. 114), and to notice that while the summer temperatures of these two examples are very similar, the graph for Winnipeg falls well below the freezing point in winter. See Fig. 117 for areas of the world with this type of climate.

Vegetation

The vegetation usually consists of unbroken stretches of coniferous forest, but in some parts local peculiarities of relief or winds and distance from the sea may reduce the rainfall and cause a poleward extension of the grasslands into the forest belt, as in Alberta and Central Siberia. The principal trees of this forest belt are various species of pine, fir, spruce, and larch intermingled with birches, aspens, and other trees with broader leaves. The birch extends polewards beyond the limits of the conifers. The northern limit of tree growth is marked by the summer isotherm of 50° F. The coniferous forest belt has light rainfall and severe winters with strong winds, therefore the trees must store food. Their needle-shaped leaves provide the minimum of exposed leaf surface, and their conical shape makes for stability in strong winds. The trees have a large proportion of wood to leaf, and it is in the wood that food reserves are stored. There is little undergrowth in the coniferous forest. The ground freezes to a depth of 3 ft. to 5 ft., and shallow-rooted plants would therefore perish. The accumulation of resinous pine needles and the prevailing darkness of the forest also limit the undergrowth. Over wide stretches of these forests there are only 7 or 8 kinds of trees, and sometimes over large areas trees of a single kind only are to be found. This makes lumbering easier, for this type of forest is one of the world's most important reserves of soft timber from coniferous trees—known commercially as " deal."

Stages of Development

As in the deciduous forest four stages of development can be traced: (1) trapping; (2) lumbering; (3) agriculture; (4) mining, if minerals exist.

In the first stage trappers hunt animals such as the squirrel, fox, ermine, skunk, beaver, and marten for their valuable furs. Just as there are few types of trees in the coniferous forest,

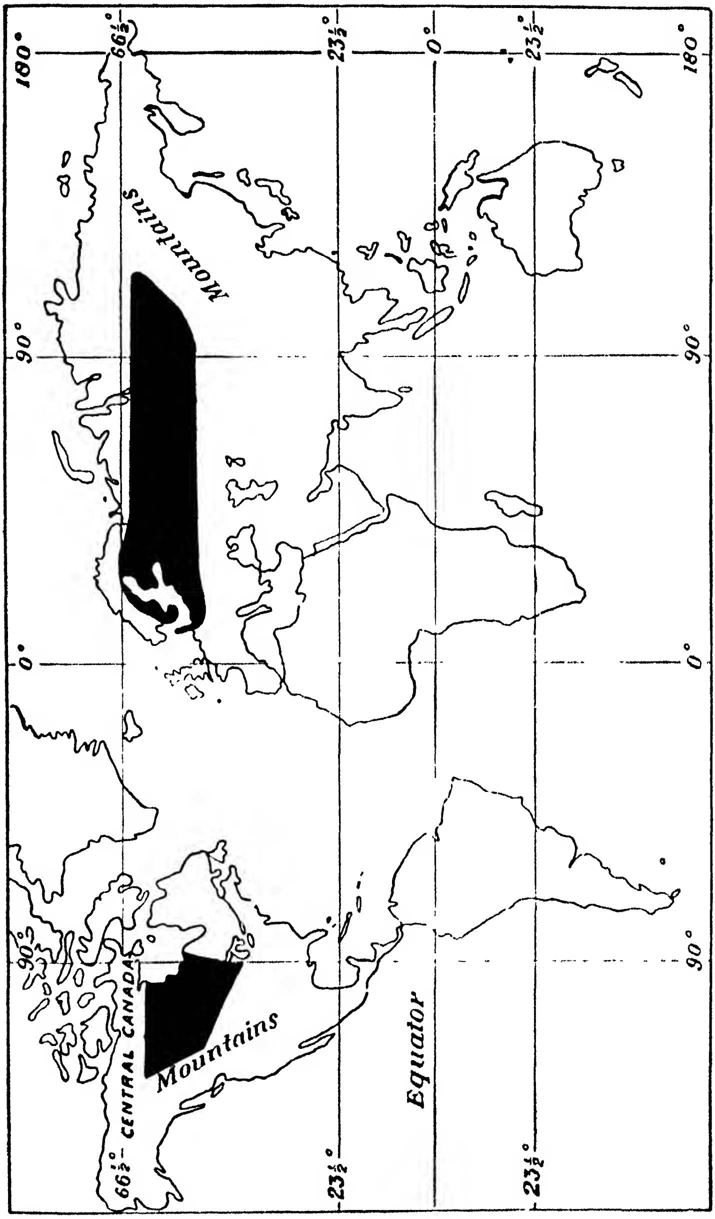


Fig. 117. Regions with Siberian Type of Climate.—1. Note that owing to the narrowness of the southern continents there are no areas with great extremes. 2. The area around the Baltic Sea may be considered as a transition zone between British and Siberian types, *i.e.* having a greater range than the former but not such a great range as the latter.

so the numerous fur-bearing animals which live within its depth are relatively few in species.

The severe winters, the frozen ground, and the snow covering make lumbering relatively simple. Agriculture has followed lumbering in the clearings, and minerals are known to exist in both the regions of this type.

There is, however, a great contrast in the development of Central Canada and of Central Siberia. This may be due to a number of causes briefly enumerated below.

(1) There is, in Siberia, no great E.–W. waterway comparable with the St. Lawrence and the Great Lakes, providing easy transport and leading to the busiest section of the Atlantic Ocean.

(2) The chief rivers of Siberia (Obi, Yenesei, and Lena) flow north into an ocean which is frozen for nine months of the year.

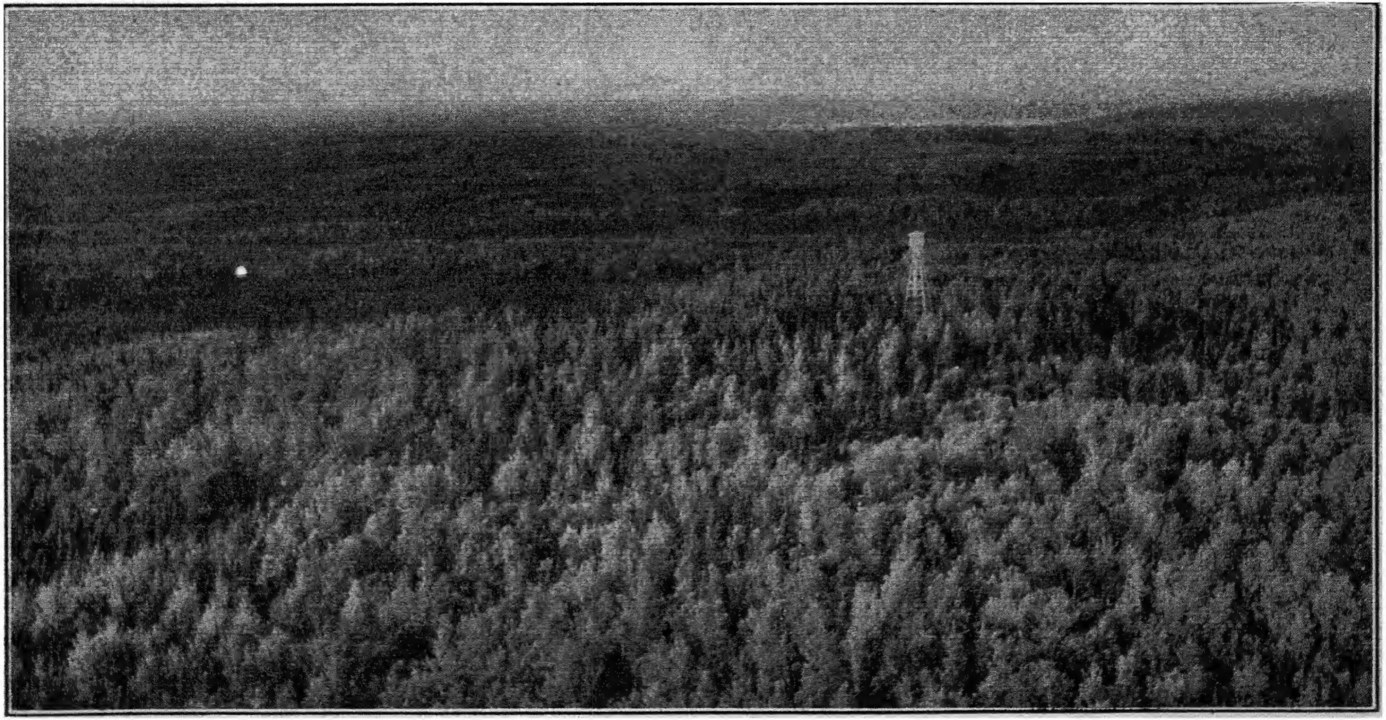
(3) Railway development in Siberia (until the second Five Years' Plan, 1932-7) has been very much behind that of Central Canada.

(4) Central Canada has been settled and developed by the peoples of western Europe, while Siberia, in the hands of an unprogressive Russia, was not exploited. This was partly due to its vast size, its isolation, the lack of capital, the presence of penal settlements, the political difficulties, and the greater attractiveness of other areas such as Central Canada.

(5) European settlers from countries other than Russia were not encouraged to settle in Siberia.

In recent years the U.S.S.R. has turned attention to the development of the Siberian lands, and there has been a rapid rise in agriculture (wheat production as in Canada), lumbering, mining, and manufactures.

Lumbering is an *exhaustive* industry, *i.e.* like mining and hunting, it results in a depletion of natural resources. For centuries, therefore, the world has been growing poorer in its resources of timber. The rate at which trees are removed during lumbering operations causes this industry to be transitory. When all the available timber of a region has been cleared the lumbermen must move on. For this reason the dwellings are of a semi-permanent character (log-huts)



Director of European Emigration for Canada

THE CANADIAN CONIFEROUS FOREST, NORTHERN ONTARIO.

Note the denseness, uniformity and extent of the forest, the lack of variety in the trees. The tower is used for observation purposes in connection with forest fire protection.

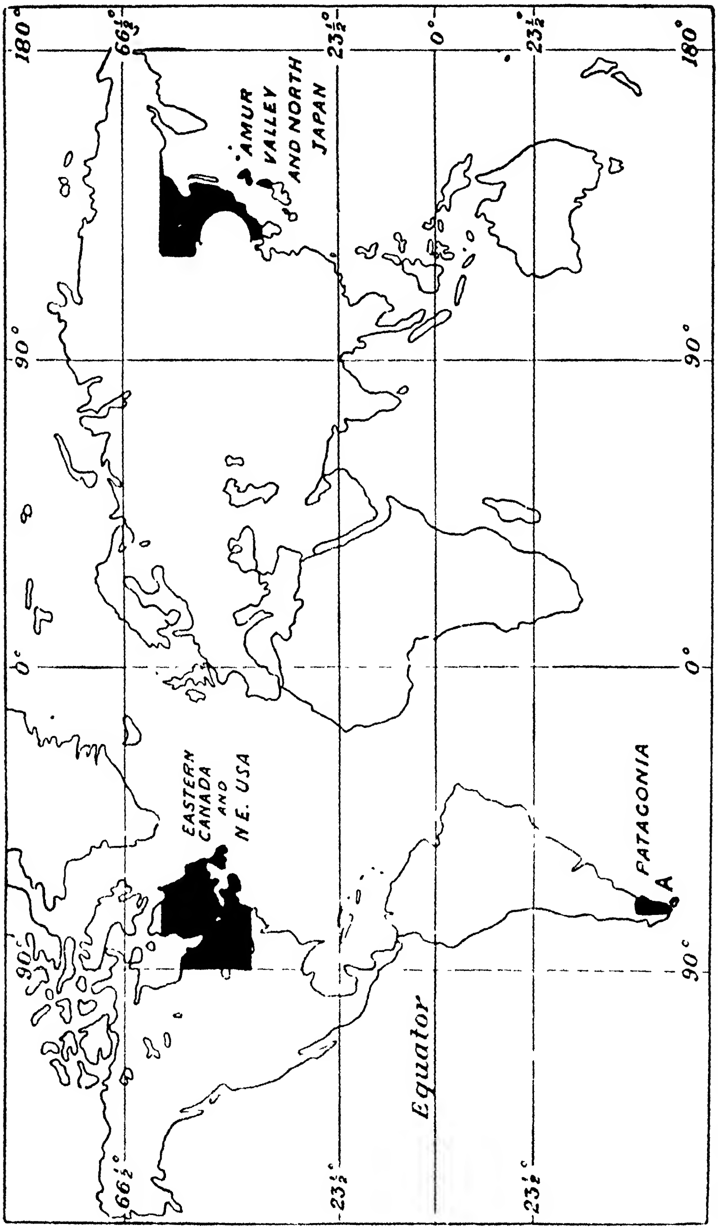


Fig. 118. REGIONS WITH LAURENTIAN CLIMATE.—See text *re* district (A) Patagonia, which is not true to type.

and the life of the lumbermen is one of hardship and isolation. Only when a policy of re-afforestation and forest conservation is introduced can there be permanent settlements and a higher standard of living.

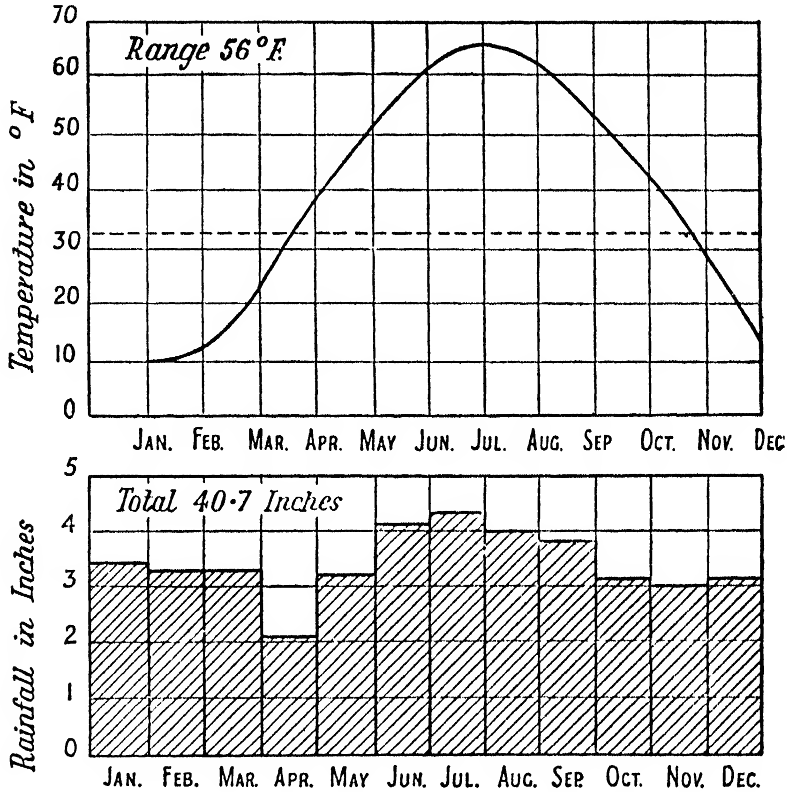


Fig. 119. LAURENTIAN TYPE. QUEBEC (296 FT.).

COOL, TEMPERATE EASTERN MARGIN OR LAURENTIAN TYPE

Climate

The climate of the Eastern Margin type (see Fig. 118 for the areas concerned) is neither so equable as that of the Western Margin, nor so extreme as that of the central zone. The difference lies mainly in the winter temperatures. It will be convenient at this point to compare the temperature graph for Quebec (Fig. 119) with those of Valentia (Fig. 114) and Winnipeg (Fig. 116). It will be noticed that there is not a

great difference in the summer temperatures of these three places, but Valentia, open to the cooling effect of the Atlantic Ocean, has a lower summer temperature than the other two stations. In winter, however, Valentia has winter temperature above 32° F., Winnipeg below 0° F., while Quebec is between 0° F. and 32° F., viz. 10° F.

It should also be noted here that while the western margin type is open to westerly winds from the ocean at all seasons, central areas like Central Canada are never subject to the moderating influence of the sea. In the eastern margins the prevalent wind in winter comes from the west, but this means that it brings the cold influences from the centre of the continent. In summer, however, the eastern margins have easterly winds from the ocean. These tend to moderate the summer temperatures, and are responsible for the summer rainfall.

The rainfall of the eastern margin is moderate in amount, 20 to 40 in., *i.e.* less than in the western margin and more than in the central zones. Thus, in rainfall as well as temperature range, the eastern margin is intermediate between the western and central zones. The rain falls mainly in summer when the winds blow inland from the sea. This can be seen very clearly if the rainfall of Vladivostok in Eastern Asia is studied. But in Eastern Canada cyclones are responsible for much winter precipitation (chiefly snow), and so the total rainfall is heavier and distributed more evenly throughout the year. The heavy winter snowfall of Eastern Canada is of great importance in relation to the lumbering industry.

One part of South America corresponds in position to this type, but it does not correspond in climate. This is the southern section of Argentina, known as Patagonia. Here the continent is narrow, and the sea influence is stronger than in the Eastern Margin regions of the northern hemisphere. Hence the range of temperature is smaller and the winters much warmer. The mean January temperature is above 32° and not below 32° F. as in the Laurentian areas of the northern hemisphere. The Andes shelter this region from the westerly winds, and consequently it has little rainfall (under 10 in.), so that it must be classed as a desert. Much of it is covered with scrub and poor pastures which are used for sheep rearing.

Vegetation

The vegetation is coniferous forest for the most part, and this type of region is part of the great forest belt of the cool temperate zone (Fig. 111). But in the extreme south-east of such regions, as in the St. Lawrence valley and New England in America, and Manchukuo in Asia, deciduous trees flourish, viz. the maple in Eastern Canada, and various kinds of oak, beech, etc., in Manchukuo.

Development

The development of these regions should follow much the same plan as was noted for the Central Siberian type, viz. (1) trapping is followed by (2) lumbering and the development of industries resulting from large supplies of wood. When the land has been cleared of trees, (3) agriculture of some kind follows, where soil conditions permit. Later, the discovery of minerals may lead to the development of (4) mining and manufactures.

The east of Canada is at present more highly developed than the east of Asia, but the timber resources of Manchukuo are being exploited to supply Japan with wood.

CHAPTER XV

NATURAL REGIONS—THE WARM TEMPERATE LANDS

Classification

According to the simple scheme outlined in Chapter XII., the warm temperate lands, excluding highlands, may be divided into:—

(1) Western Margin or Mediterranean Type.

(2) Central or Steppe Type.

(3) Eastern Margin or Chinese Type (sometimes called Temperate Monsoon Type).

The warm temperate belt lies roughly between latitudes 30° and 45°.

THE WESTERN MARGIN OR MEDITERRANEAN TYPE

Climate

All natural regions of this type (see Fig. 120) have a climate similar to that of most of the lands bordering the Mediterranean Sea. As stated in Chapter XII., the winds of these regions are wet Westerlies from the ocean in winter, and dry Trades from the land in summer. This general statement, however, will be subject to modifications when a more detailed study is undertaken.

The summers are hot, over 70° F., and over 80° F. away from the sea, as in central South Italy. The winters are warm, averaging about 50° F. Rainfall comes mainly in the winter months and varies from 30 in. on the poleward side to 10 in. on the desert side. One area, that around Trieste, has over 80 in. annually. The poleward side of the Mediterranean areas usually has one summer month without rain, as in South France, but on the desert borders there may be as many as seven dry summer months, *e.g.* Tripoli.

The example taken as an illustration, Palermo, is on the island of Sicily, and is therefore centrally placed in the

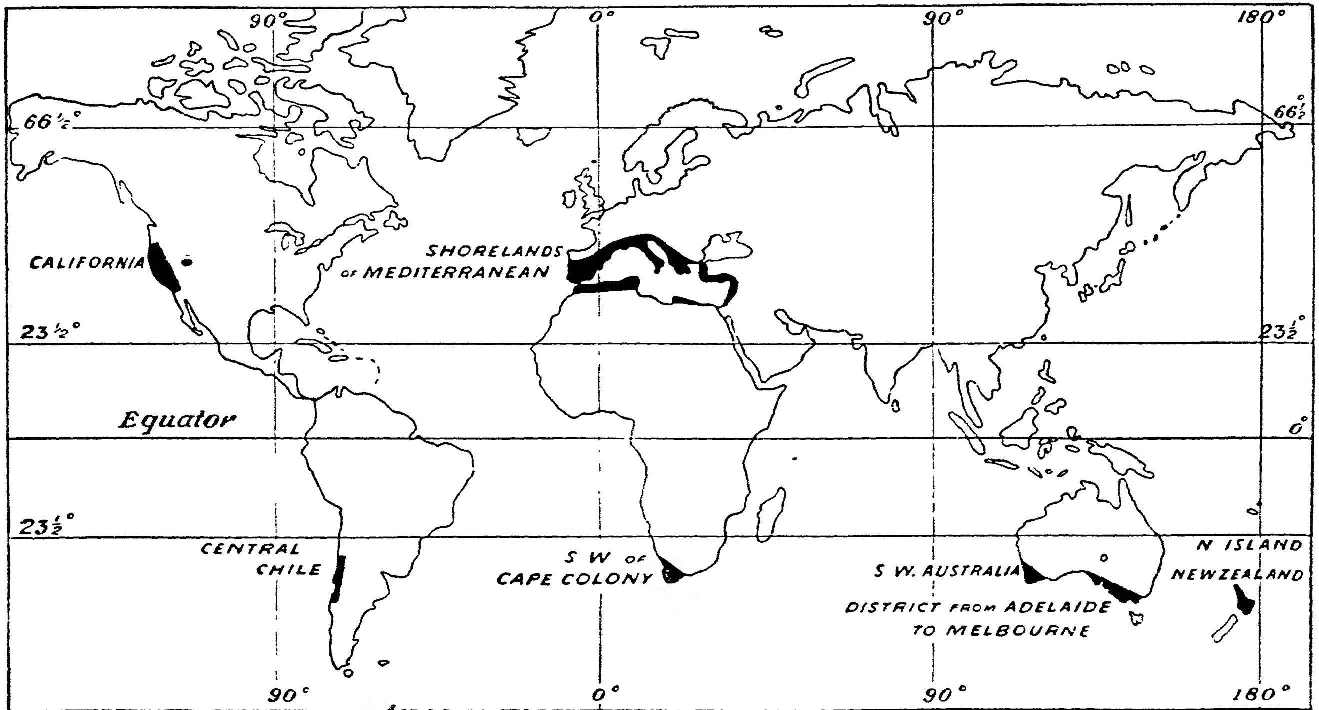


FIG. 120. REGIONS WITH MEDITERRANEAN CLIMATE.

N.B.—The climate of North Island, New Zealand, is not exactly of the Mediterranean type, and some authorities classify it as a "British" type. Even on the shorelands of the Mediterranean Sea some places, *e.g.* Venice, are not typically "Mediterranean."

European Mediterranean area. It has three summer months when the rainfall is practically negligible. The range of temperature is from 77° F. in summer to 50° F. in winter, *i.e.* 27° F. (Fig. 121).

Vegetation

The vegetation of this type may be classed as broad-leaved evergreen forests, woods, and shrubs. During the mild, wet

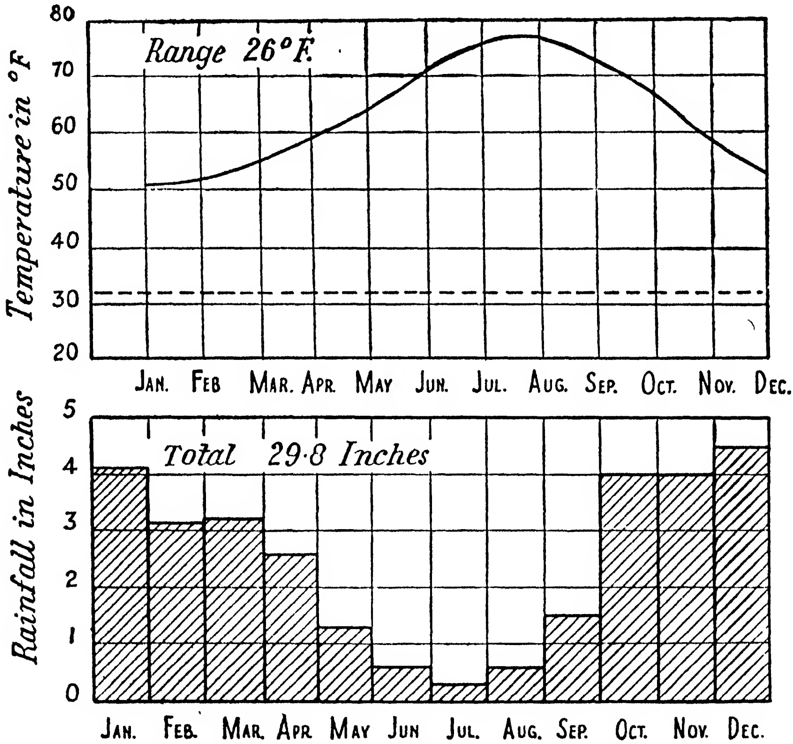
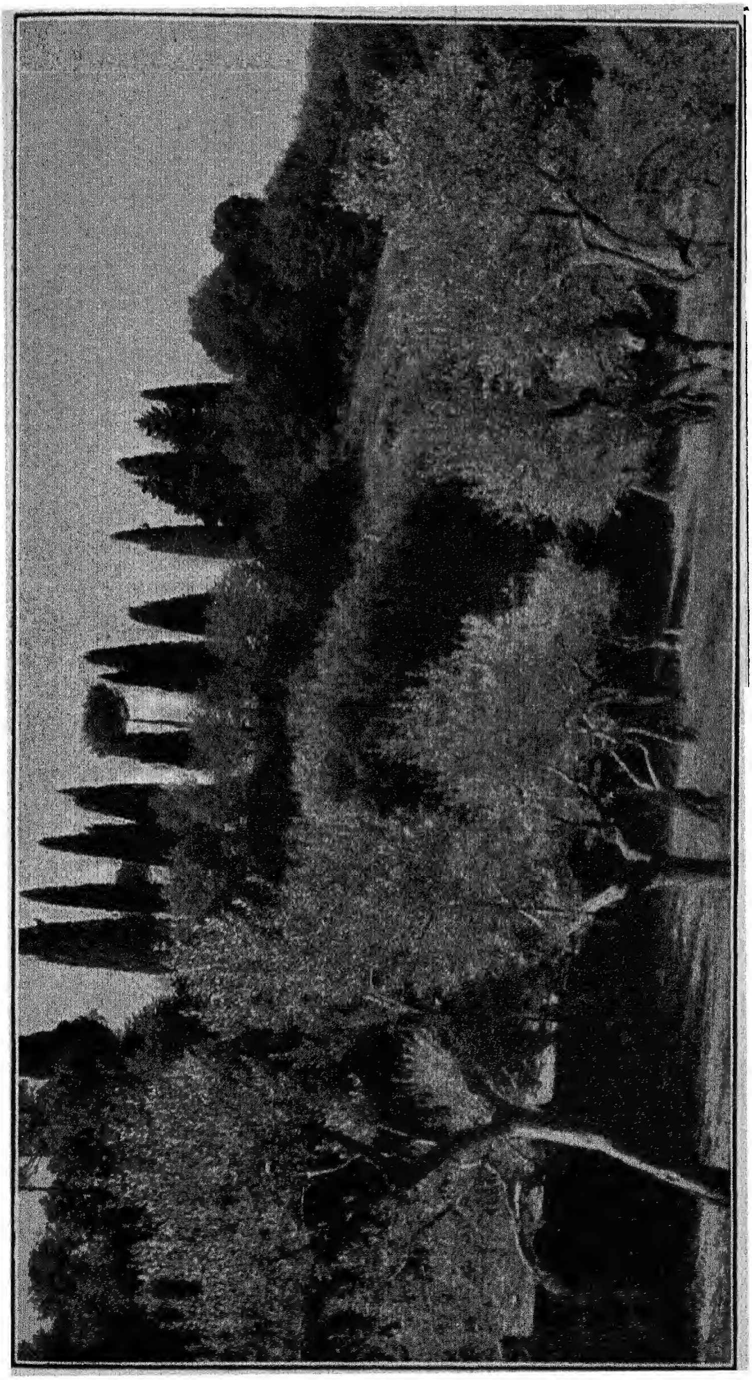


Fig. 121. MEDITERRANEAN TYPE. PALERMO (230 FT.).

winters slow growth is possible. The summers, while not absolutely rainless, are dry so that in this season plant growth is again slow. Typical Mediterranean trees are adapted to this slow growth and to the summer drought by being compact and woody. Plants must protect themselves against excessive transpiration so that the evergreens have hard, small, and often glossy leaves, bluish and greyish-green in colour. Water-storing plants are also characteristic of these regions, hence



F. Henle

MEDITERRANEAN VEGETATION, FRASCATI, NEAR ROME.
Notice the olive trees in the foreground and the cypress trees in the background.

bulbous flowers are common, and also plants like the aloe, with thick sword-shaped leaves. The trees do not compare in size with the large woodland trees of the British Isles, and the absence of shade is a distinct feature of the Mediterranean lands. There is little green pasture comparable with English pastures, for the summer drought prevents the growth of rich green grass. Various types of vegetation may be identified, such as forests of cork oak, groves of fig trees and olive trees, and such shrubs as myrtle, laurel, oleander, etc. Where the original forest has been destroyed it is often replaced by a bushy scrub, known in Corsica as maquis or macchia. The flowering plants of the maquis have earned for Corsica the name " The Scented Isle."

Cultivated plants include various cereals (wheat, barley, etc.), and a large variety of fruits, such as olives, figs, oranges, lemons, peaches, apricots, plums, grapes, pomegranates, and almonds, and other varieties of nuts. Of all these plants the *olive* is the most characteristic. In fact, it may be assumed that wherever olives grow the climate must be of the Mediterranean type, and that a map showing the distribution of olives will show the limits of true " Mediterranean " areas.

Development

Mediterranean regions do not pass through the same sequence of development as the cool temperate regions already discussed, though in the more recently developed regions outside Europe four stages of development may often be traced: (1) a search for precious metals, *e.g.* gold in California; (2) the rearing of animals for hides—meat products could not be exported before the introduction of refrigeration; (3) the growing of fruit; and (4) development of agricultural industries, viz. wine making, fruit drying, the extraction of olive oil, etc. While it is possible to trace most of these four stages of development in the Mediterranean areas beyond Europe, the development of the region around the Mediterranean shores goes back so far that it is not possible to trace the pioneer stages.

Forests are not extensive, and the wood of the trees has little value as timber, though some trees are of special importance, for example, the cedar for its wood, and the cork oak for its bark. The assured spell of fine, dry, sunny weather in

the summer has made these regions important for fruit growing and drying and for agriculture. The climate is ideal for wheat, particularly the hard varieties for the making of such products as macaroni. But the configuration of all Mediterranean regions is such that in none of them are there extensive plains comparable with those of Central Canada. Hence the Mediterranean regions are not, in spite of the good climate, the great wheat-producing areas of the world.

A survey of the "Mediterranean" regions shows that coal is rarely found, and never in large quantities. Hence large manufacturing and industrial areas comparable to those of North-Western Europe and the North-East of U.S.A. have not developed. Industries do exist in these regions, but they are for the most part the result of the abundance and variety of fruits, *e.g.* the manufacture of wine, olive oil, etc. Individual cities may have textile, engineering, and other industries (viz. Barcelona, Naples, Milan, Turin, and Marseilles), but they are not centres of great industrial areas as are Birmingham (Central England) or Dusseldorf (Ruhr Valley).

THE WARM, TEMPERATE CENTRAL LOWLAND OR STEPPE TYPE

Climate

The central areas of continents are far-removed from the sea, hence they are regions of great extremes of temperature. The summers are hot (over 80° F.), and the winters very cold (below 32° F.). The rainfall is light (about 20 in. annually), and falls mainly in the spring and early summer. This rainfall is of the convectional type (see Chapter X.).

The example (Fig. 122) taken to illustrate this climate is Bismarck, a town in the state of North Dakota (U.S.A.). As it is 1674 ft. above sea-level the temperatures are reduced by about 5° F. Examples taken from the Asiatic steppe land have a very light rainfall (under 10 in.) because of the great distance from the sea. Graphs drawn for towns in the steppe lands of the southern hemisphere do not show the extremes of temperature typical of the steppe lands of the northern hemisphere. This is because southern continents are narrower in temperate latitudes and sea influence is nowhere completely absent. The range of temperature in the southern hemisphere

is greatest in Argentina, where it is about 30° F. This is small compared with the ranges of 50° F. to 70° F. found in the northern steppe lands. Fig. 123 shows the steppe land areas of the world.

Vegetation

Steppe lands are grasslands. These rolling plains extend as far as the eye can see, with nothing to break the dull uniformity

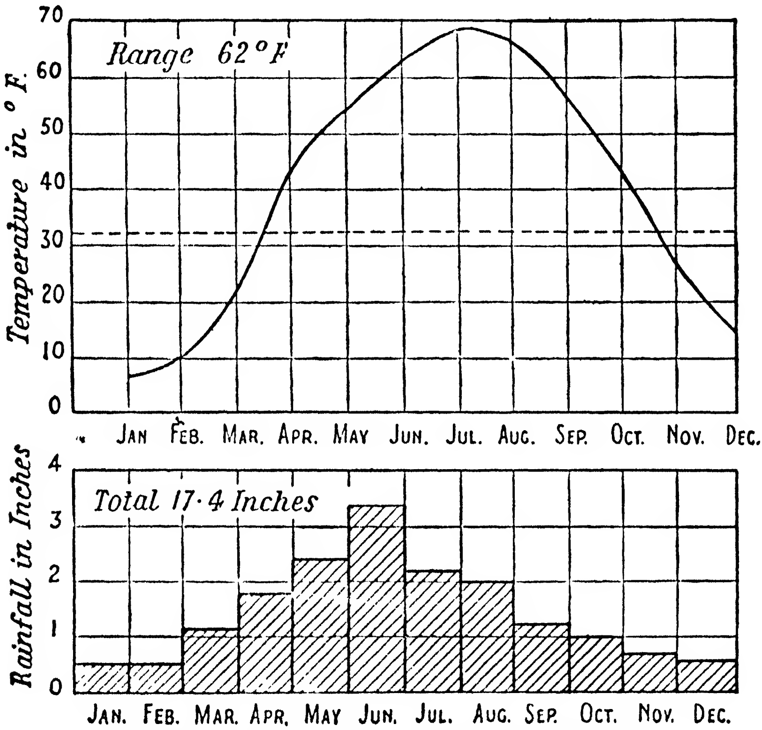


Fig. 122. STEPPE TYPE. BISMARCK (1674 FT.).

and monotony of the scene—not even a tree. The extreme cold and dryness of the winters coupled with the scanty rainfall and intense evaporation makes tree life impossible except along the water courses where willows, poplars, alder, etc., grow. The grass is not like that of our English meadows, green and juicy, but consists of stiff, hard, dryish grass, with blades curling inwards, and is often greyish-green in colour. In the Argentine pampa the grass often grows in tufts between which the bare soil is exposed.

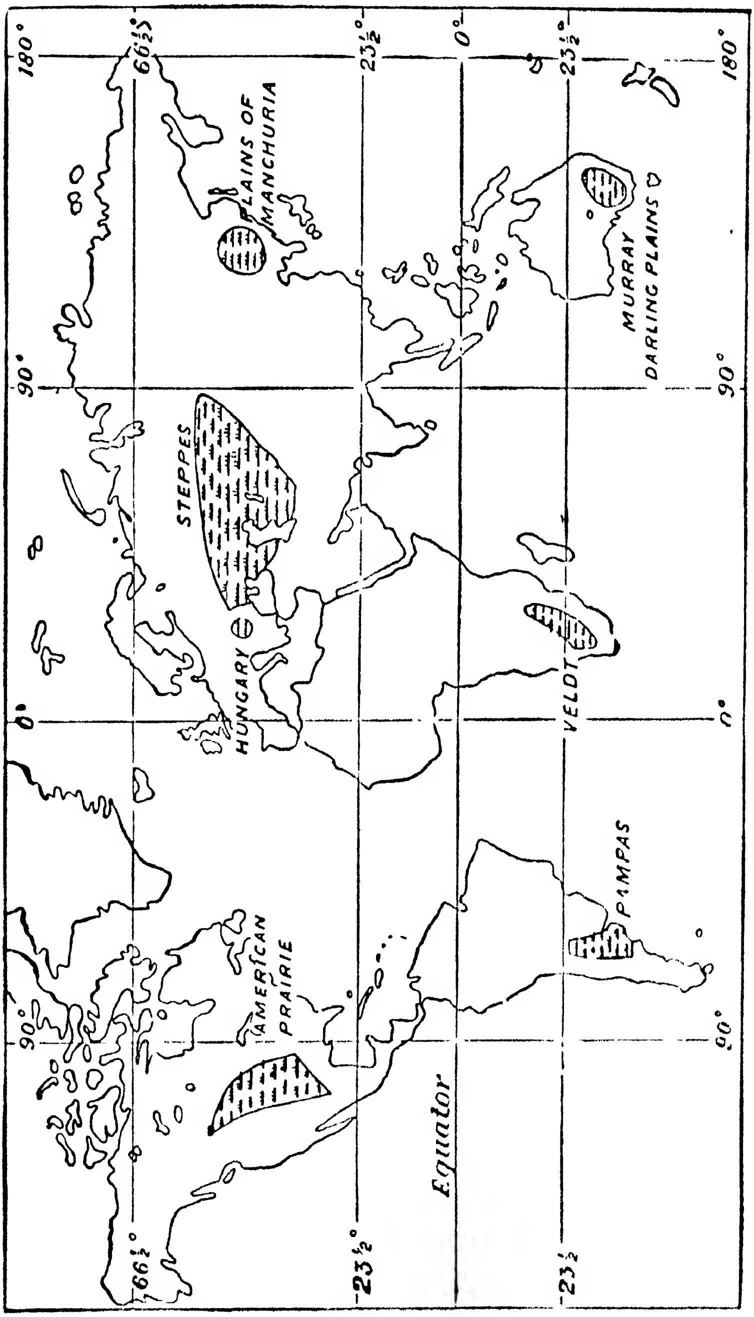


Fig. 123. Steppe Land Regions.

The appearance of the steppe varies with the season. In the early spring fresh green grass is bestrewn with the gay colours of myriads of flowers. Later in the year the grass becomes parched, dry, and brown as a result of the heat and drought. In autumn, in some steppe areas, a dry greyish-green vegetation may spring up which gives the steppe the appearance of a region of sage brush. In winter the steppe is bare and often snow-covered.

Where the rainfall approaches or exceeds 20 in. trees may occur, but where it diminishes to 10 in. the vegetation is poor scrub with thorny plants and the land becomes a semi-desert region.

Development

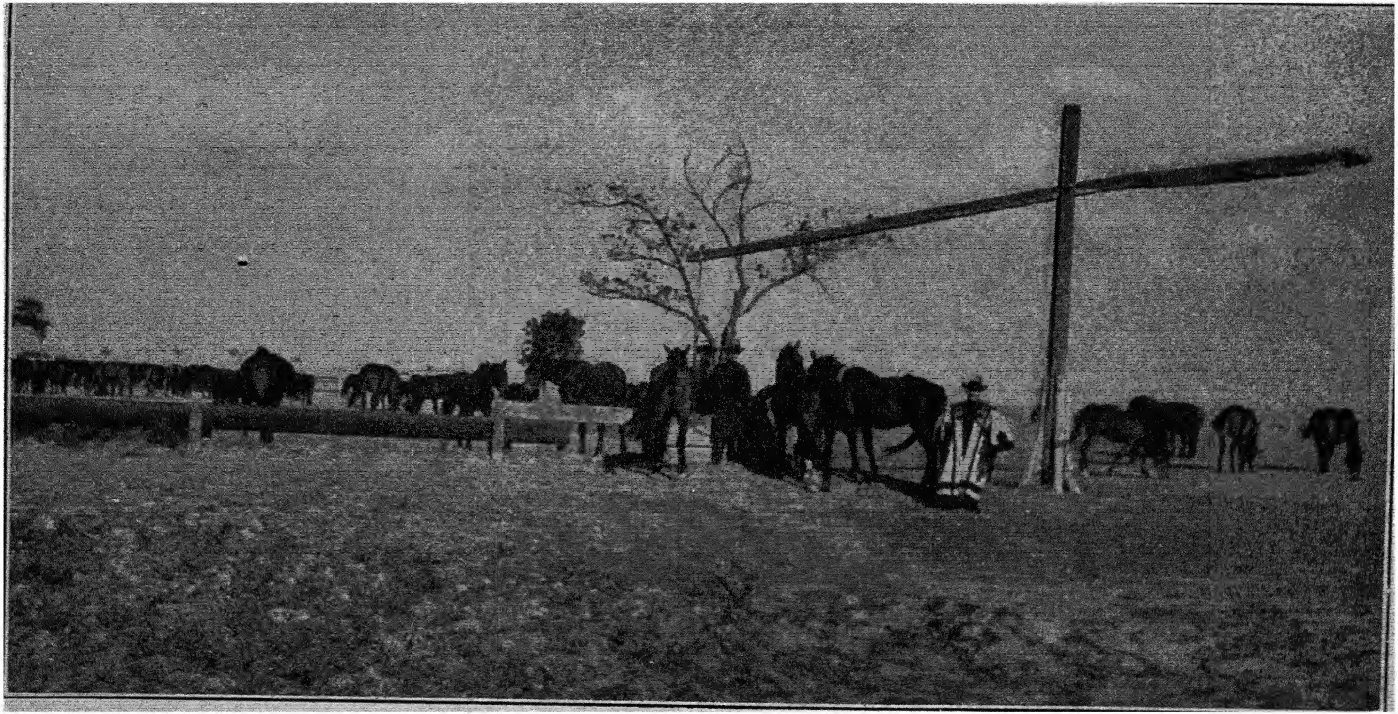
In steppe lands there are four phases of development.

(1) The earliest stage is that of nomadism, the scanty population being hunters, constantly on the move in search of food. Later, if the animals native to the region are suitable for domestication, as in the plains of Eurasia, the nomads would be herders wandering over large areas in search of fresh herbage for their animals.

(2) The opening up of these plains by more advanced peoples leads to the rearing of animals by different methods, ranches and sheep runs with fixed homesteads taking the place of the pastoral nomadism and portable homes.

(3) In the damper and more fertile areas the steppes are ploughed and made to produce a wide range of temperate crops. Gradually the drier steppes, by means of irrigation and dry farming, are being cultivated.

(4) Industry is now spreading to the more advanced of these regions. The industries are of a specialised type. Just as the industries of the Mediterranean regions are related to fruit and other agricultural products, so the industries of the steppe land areas are based on the agricultural products and the animals that are reared. Such industries include the manufacture of cereal foods and starch; the canning of meat; the making of meat extracts; all forms of leather manufacture; bacon curing; refining of lard; and manufacture of margarine, glue, and bone and horn articles. In some regions, notably



Hungarian Legation

HORSES AT THE WELLS OF HORTOBAGY, HUNGARY.
The flat plains of the middle Danube are almost treeless, though occasionally drought-resisting acacias are planted near the wells to provide shade.

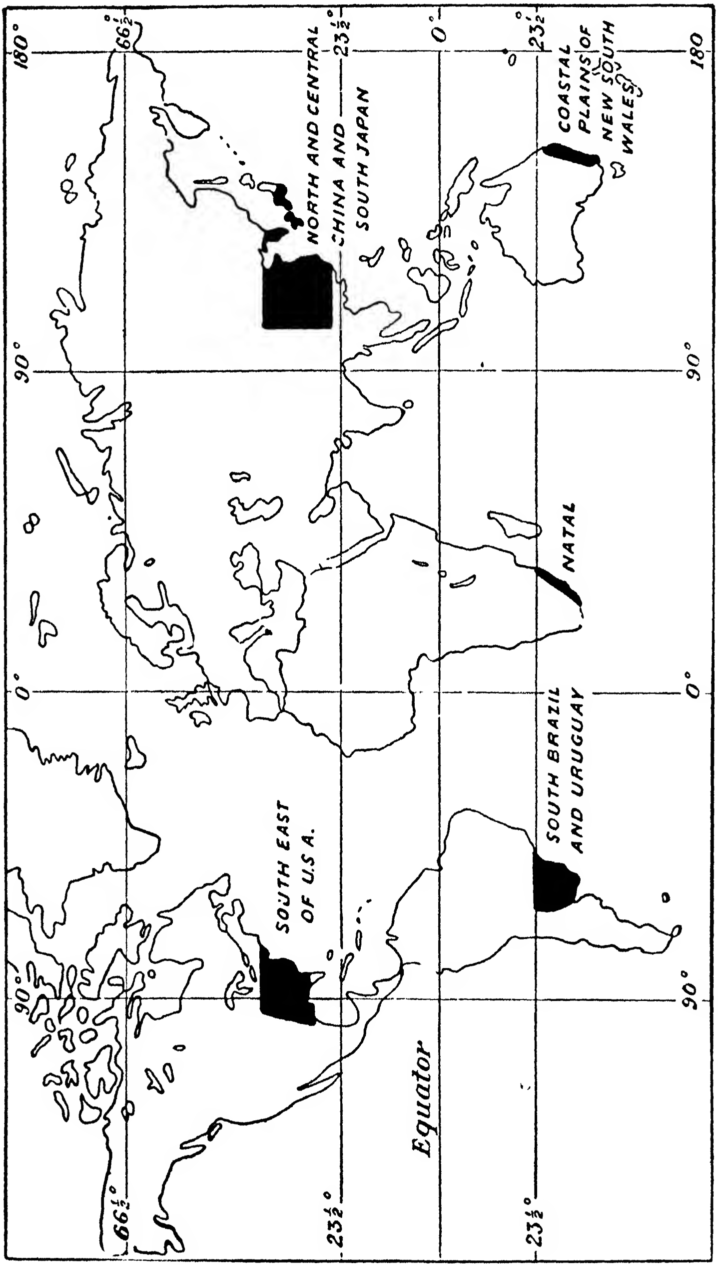


Fig. 124. Regions with China Type Climate, *i.e.* Temperate Monsoon.

the Central United States, coal underlies the surface rocks, and this has helped to promote the industrial development.

A steppe land region does not necessarily pass through all these stages in succession, nor have all the steppe lands reached the same stage of development. In the steppes of Central Asia there are still large numbers of pastoral nomads, though the U.S.S.R. is rapidly developing the moister areas for agriculture. In America the damper prairies are used for grain growing and other agricultural pursuits, while the drier areas are great ranching lands.

The grasslands of Australia are mainly used for sheep runs, while agriculture and stock rearing are both important, as also in the veld of South Africa.

WARM, TEMPERATE EASTERN MARGIN OR CHINA TYPE

Climate

This natural region (see Fig. 124) is sometimes referred to as the Temperate Monsoon type, for wet winds blow inland to the continental low pressure area in summer, and dry winds blow seawards from the continental high pressure area in winter (see Chapter XI.). The summers are hot (80° F.), and the winters, being subject to cold winds from the land, are much colder than the winters of the western margin Mediterranean areas. The rainfall is moderate to heavy (30 in. to 50 in. annually), and falls all the year round with most in the summer half-year. These facts are illustrated by the graphs for Shanghai (Fig. 125). In the American area the winter rain is brought by cyclones, and in the Asiatic area by the recurving of the out-blowing winds, back towards the coast.

Just as the Laurentian type (on the east side of a continent) has much colder winters than the British type (on the west side of a continent), so the China type (east side of continent) has much colder winters than the Mediterranean type (west side of continent). Lisbon and Pekin (Peiping) are almost in the same latitude, but the river Tagus at Lisbon never freezes, while the river Pei-ho at Pekin freezes nearly every winter. It would be advantageous to make a comparative study of the Palermo and Shanghai graphs.

In the southern hemisphere the regions termed " China type " are somewhat different. They have a smaller range of temperature, the winter temperatures being raised by sea influence. There are no true monsoons, and the S.E. Trade Winds blow on-shore at all seasons, so that rain falls all the

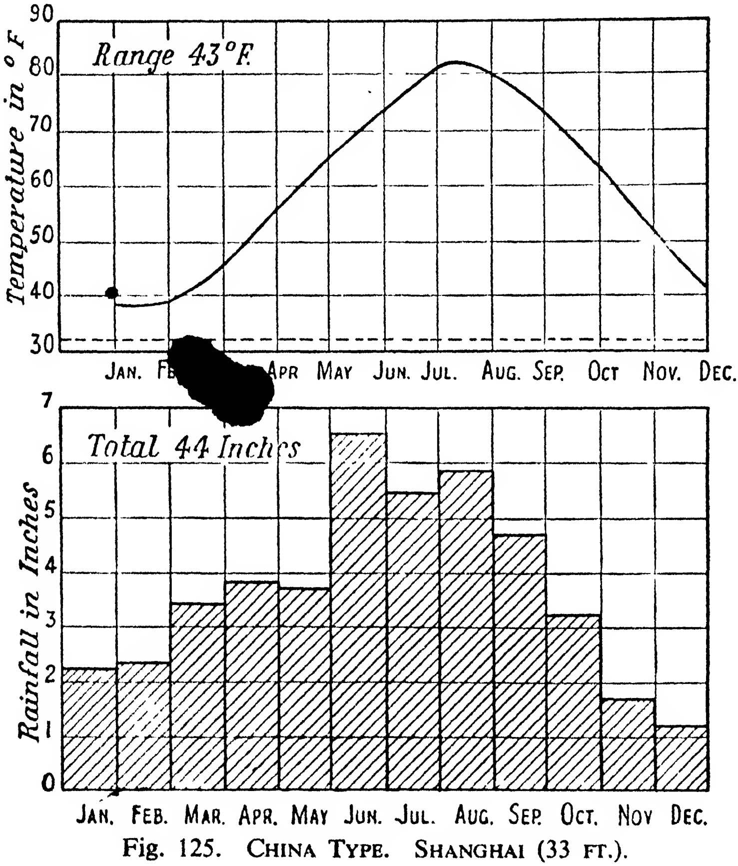


Fig. 125. China Type. Shanghai (33 ft.).

year with most in summer, when the Trades blow more strongly towards the heated interiors of tne continents.

Vegetation

The natural vegetation of these regions is a luxuriant type of deciduous forest on the lowlands and conifers on the high land areas, as in the Appalachians, the Blue Mountains of Australia, the pine forests of Southern Brazil, and the Drakensburg Mountains in South Africa.

The forests include many types of trees similar to those of more northerly latitudes, *e.g.* beech and oak, and in addition, magnolias, camelias, and camphor trees, etc. There are also tree ferns, small palms, bamboos, and a wealth of flowering shrubs. The variety and wealth of flowers and the denser undergrowth are the main differences between these forests and those of the cool temperate deciduous forests such as are found in Britain. Many of the trees and shrubs are important commercially: some for their timber, and others for camphor, tea, gum, etc.

Development

The development of that part of Asia which is of the "China" type dates so far back that it is difficult to trace any successive stages. In the other five regions colonisation is recent. These lands were, by nature, forested, and extensive forest areas still remain, particularly on the mountain slopes, *e.g.* the Blue Mountains in New South Wales. The lowland forests are composed of deciduous trees, and these must be cleared before agriculture can be practised. But lumbering has never become as important as in the St. Lawrence area. The absence of snowy winters led to increased difficulty in transport, and inability to compete with the lumber areas of the cooler latitudes. The wood of deciduous trees is "hard" wood, and for such there is a smaller market than for the softer and more easily worked wood of the conifers. In the S.E. of U.S.A. much of the wood was cut and burned on the spot, an economic waste which was not realised until the treeless lands west of the Mississippi were opened up. Then the shortage of wood, the increased demand, and the consequent rise in prices led to a policy of careful conservation of timber reserves.

On the lands thus wastefully cleared a variety of crops have been grown, which vary according to the available labour supply and the nationality of the settlers in each district. For instance, in U.S.A. where there was abundant slave labour, cotton, tobacco, rice, and sugar are the principal crops. In Natal similar "hot" crops, *e.g.* sugar, rice, tea, pineapples, etc., can be grown because the available labour supply includes not only native negroes, but Hindus and Chinese. In the S. American region which includes Uruguay

and Southern Brazil, the occupations are mainly pastoral, including the rearing of cattle, horses, and sheep, though the vine, sugar, maize, and bananas are being grown in limited areas, notably the hinterland of Porto Alegre. In the coast-lands of New South Wales there is no coloured population, and the agriculture is more "temperate" in type. Dairying and mixed agriculture occupy a large percentage of the land. Mediterranean fruits are grown, and "hot" crops such as sugar, are cultivated only in the extreme north of the region.

The development of industries in these regions, with the exception of Southern Japan, is still in its infancy. The latter district has, in recent years, made rapid strides as a manufacturing area. Manufacturing industries are now developing rapidly in the south-east of the United States, but in the remaining areas industries are comparatively few, and those that do exist are based on agriculture, or else are branch factories of European firms often established to avoid import duties in the countries concerned.

CHAPTER XVI

NATURAL REGIONS—THE HOT LANDS

Classification

According to the scheme outlined in Chapter XII., the hot lands (roughly lying between 30° N. and 30° S.) can be divided into four natural regions:—

(1) Hot deserts, Sahara type.

(2) Savana grasslands, Sudan type.

(3) Hot east coast:—

(*a*) Monsoon areas, Indian type.

(*b*) Trade Wind areas, Caribbean type.

(4) Equatorial areas, Amazon type.

HOT DESERTS

Climate

Hot deserts are found on the western margins of land masses, and lie, approximately, between latitudes 20° to 30°. The controlling factors in the climate of these regions are the high pressure belt (Horse Latitudes) and the drying Trade Winds, blowing off-shore. Thus rainfall is deficient, always under 10 in. annually, and in some places rain only falls once in five or six years. When rain does fall the showers are often torrential. The average annual rainfall of Iquique in South America, for instance, is ·03 in. The coasts of all hot deserts are washed by cold currents flowing towards the Equator. These reduce both the temperature and the rainfall. Because the sky is almost cloudless, night temperatures are very low, *i.e.* the diurnal range of temperature is large.

These climatic facts are illustrated by the graphs for Yuma (Fig. 126). Yuma is in the valley of the Colorado and near the boundary between the United States and Mexico.

The average July temperature in the deserts of the northern hemisphere is 90° F. and over, while the January temperatures average about 60° (*i.e.* as hot as the British summer). It is in the desert regions that the highest records of temperature

have been taken, *i.e.* 126° F. in the shade at Wadi Halfa. The summer temperatures of the desert zones are higher than the temperatures of the equatorial areas, where the temperature is reduced by clouds and rain. In the southern hemisphere such high readings are not recorded, owing to the greater influence of the ocean, and the smaller extent of the deserts, *e.g.* average summer temperatures in the Atacama Desert of N. Chile range round 70° F. Fig. 127 shows the hot desert areas of the world.

Vegetation

Not all deserts consist of large stretches of loose sand. The best example of a sandy desert is the Igidi region south

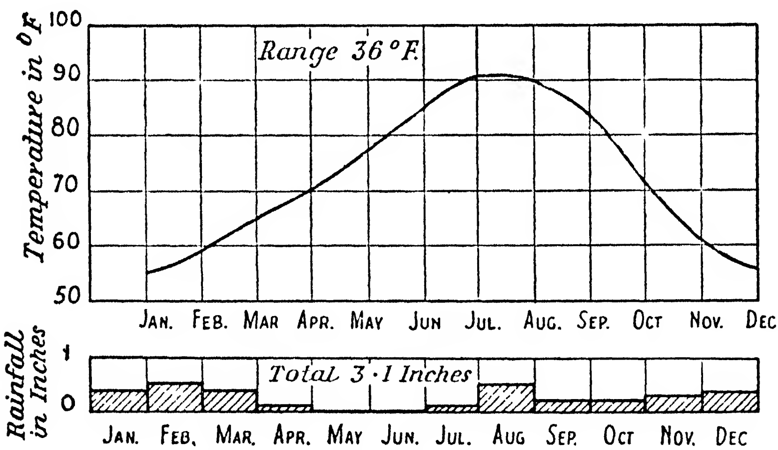


Fig. 126. Desert Type. Yuma (141 ft.).

of Morocco, where sand dunes are often 600 ft. high. In some cases the desert consists of dry baked clay, and in others of bare rock surface covered with broken rocks and boulders. Desert zones are generally taken to include all areas with less than 10 in. of rainfall, and are therefore not entirely devoid of vegetation since 8 or 9 in. of rain will support a thorny scrub or rough pasture (*e.g.* the American sage brush).

The desert vegetation consists entirely of plants that have to withstand long periods of drought. Thus there is, in America especially, an immense variety of cacti. Grass is of the tough, wiry variety, and there are numbers of small thorny bushes. In places where ground water comes near to

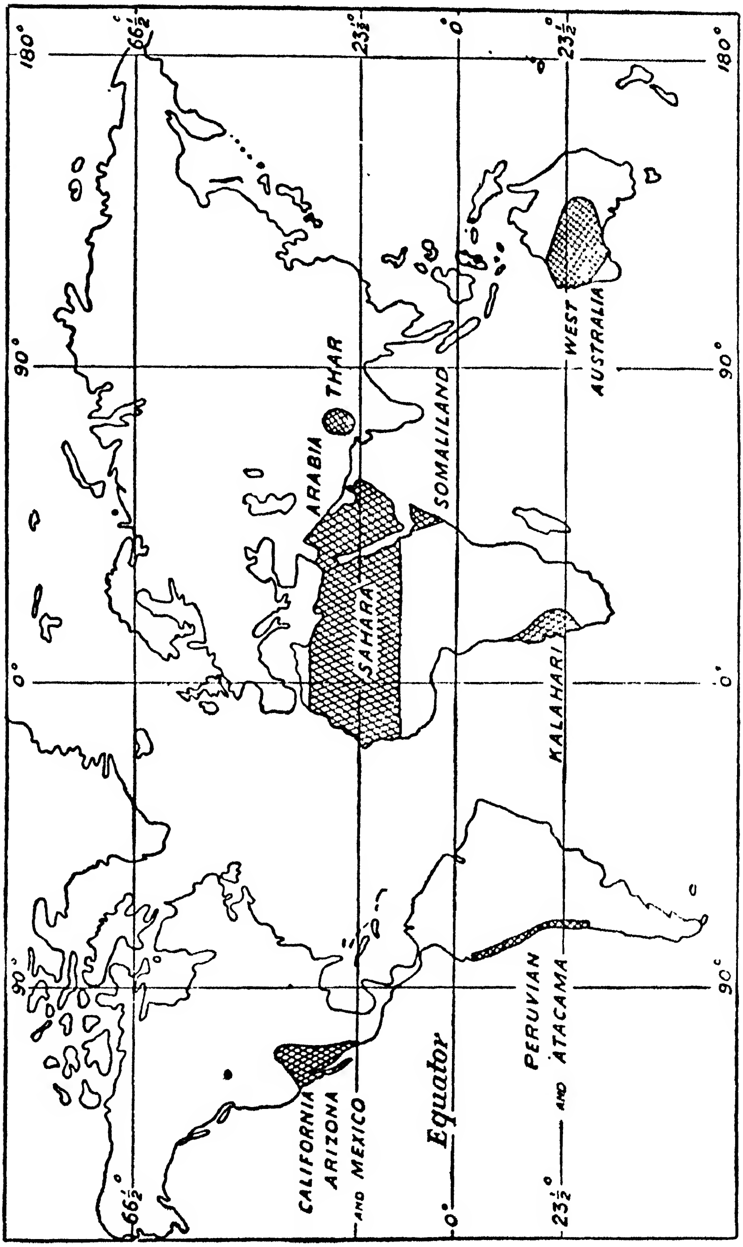
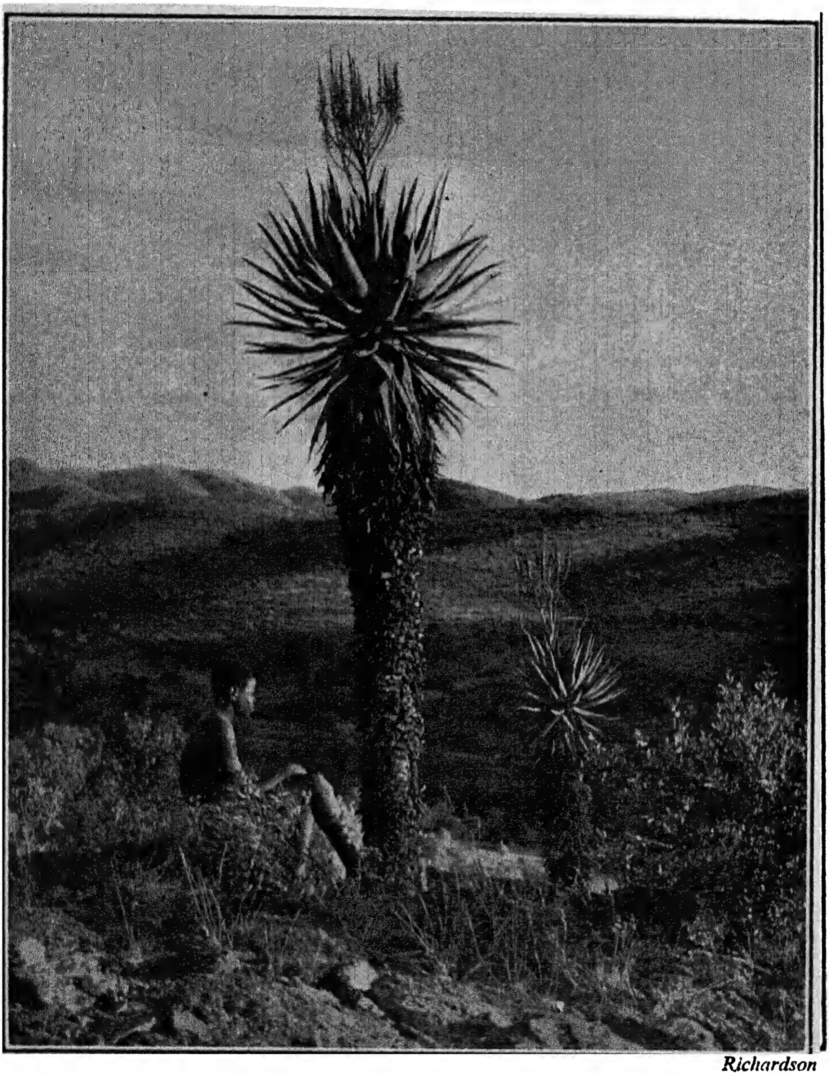


Fig. 127. The Hot Deserts.

the surface there are oases, which show clearly how fertile the desert soil is when water is available. In these oases, date palms flourish, and a great variety of products can be grown,



Richardson

THE DESERT.

This view is taken in the Kalahari Desert near Windhoek. It shows the general bareness of the land, its surface being strewn with fragments of rock. The vegetation is very sparse, consisting of shrubs, wiry grass and occasional aloes which because of their ability to store moisture are adapted to desert conditions.

such as cotton, rice, sugar, vines, millet, tomatoes, tobacco, and fruits.

In a temperate desert, such as Chinese Turkestan, the oasis vegetation will be that of the temperate zone, viz. willows, etc. Oases are often very large, covering one hundred or more square miles (*e.g.* Tafilet), and supporting relatively large populations (*e.g.* Damascus).

Development

Desert regions, because of their rainfall, are scantily populated areas where little development has taken place. The inhabitants of desert zones fall into three main categories:—

(*a*) Primitive peoples who have been driven to the poor scrub lands by stronger tribes, *e.g.* the Bushmen of the Kalahari. Such peoples are, by nature, hunters, for whom cultivation, settlement, and permanent homes are impossible.

(*b*) Cultivators who live in natural oases or other irrigated areas. Since the certainty of dry weather ensures successful harvests, and winter temperatures are high enough for the growth of temperate crops, cultivation reaches an advanced stage. The drier borderlands of the oases are utilised by pastoralists (often nomadic) who rear sheep, goats, and camels.

(*c*) Recent immigrants who, lured by minerals and the possibility of quickly acquired wealth, face the obvious privations due to scarcity of water. Elaborate schemes for the supply of water to such mining settlements have to be inaugurated. But mineral deposits are, in time, worked out, and the population disappears, since permanent agricultural settlement is not possible.

SAVANA GRASSLANDS

Climate

These areas lie between the desert and the equatorial forest (Fig. 128). The summers are very hot (80° F. to 90° F.), and the winters are hot (70° F.). As these regions are within the tropics they are never cold, and the range of temperature is not great. The rain falls in the summer when the equatorial belt of convectional rain moves north or south with the sun (see Chapter XII.), and the winters are dry, for this is the season of the Trade Winds.

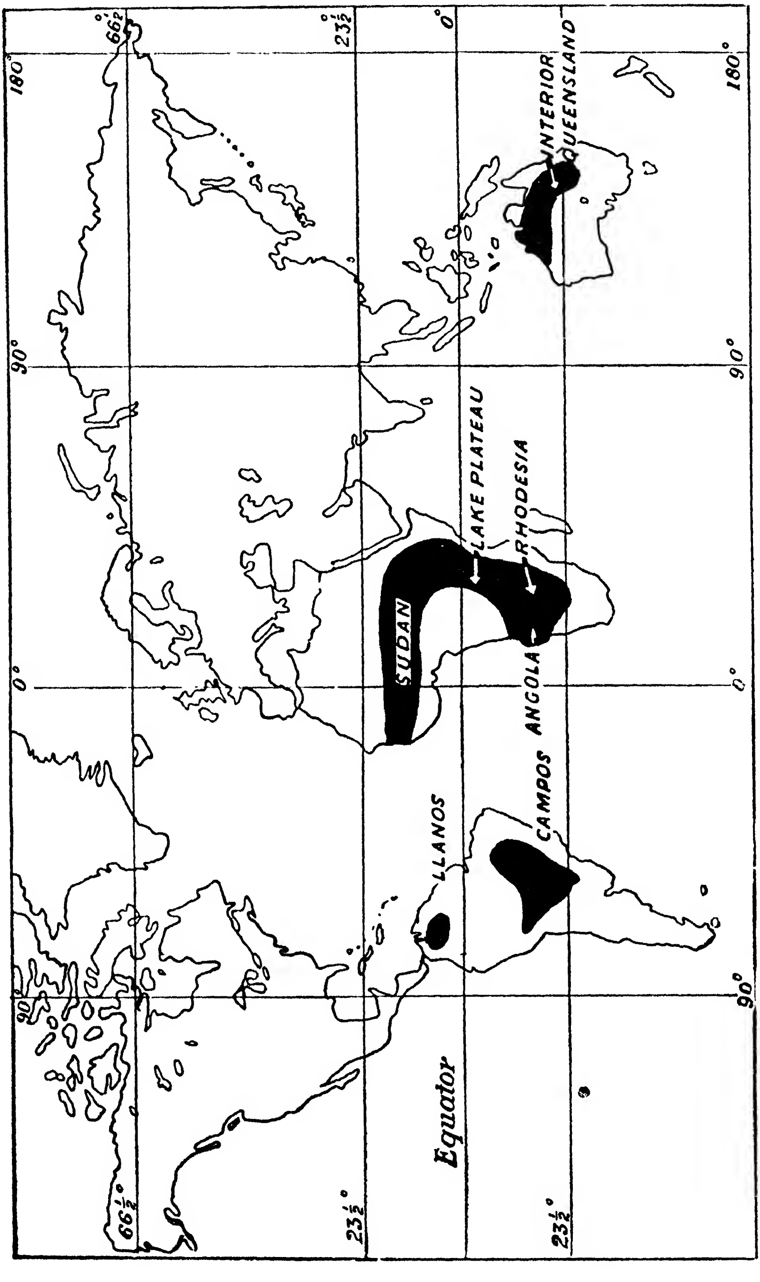


Fig. 128. SAVANA REGIONS.

Vegetation

The vegetation is grassland dotted with clumps of trees, and is often termed " parkland." Actually the vegetation varies considerably from the desert margins to the forest margins. Near the desert the grass is poor, and there are scattered thorn bushes. The grass becomes richer and trees more frequent as the forest is approached, until, finally, there are large woodland tracts, with intervening grassy areas.

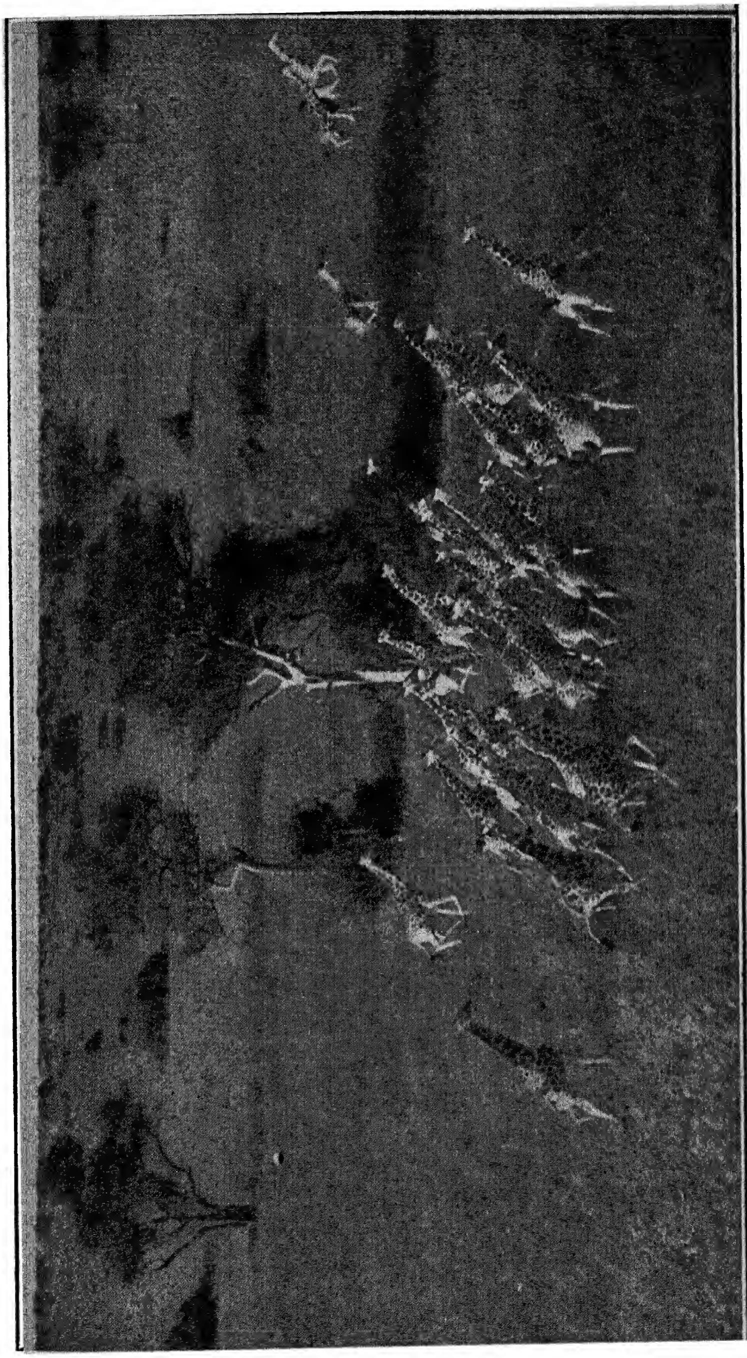
Although the savana is a grassland, it does not resemble either the English meadows or the temperate steppes. The grass often grows 5 to 10 ft. high, and has a dry appearance. In some districts impenetrable elephant grass reaches a height of 12 to 15 ft.

Development

True savanas are only found in the southern continents, and all are south of the Tropic of Cancer. Thus they are situated, not in the areas of long development, but in the more recently discovered and still undeveloped parts of the world. At first sight it would seem that since savana lands are grasslands they would follow a sequence of development similar to that of the steppe lands, viz. pastoral nomadism, settled agriculture, and agricultural industries.

The nearest approach to this sequence of development is to be seen in Africa. Many of the negro tribes throughout the grasslands of Africa are nomadic herders of cattle. Some of the negroes, *e.g.* the Hausas of Nigeria, have passed beyond this stage and are primitive cultivators. With European penetration more modern methods of culture have been introduced, and natives are encouraged to produce more than they need so that there is a surplus for export.

In the savanas of S. America and Australia conditions were not favourable for the development of pastoral nomadism. The grasslands of South America had no indigenous hoofed animals suitable for domestication. These savanas were inhabited by various types of rodents such as the chinchilla, viscacha, and capybara, animals belonging to the same family as rabbits and hares. The Australian grasslands were the natural home of animals called marsupials, of which the kangaroo is an example. In these lands, therefore, herding was not a possible occupation until the introduction of cattle,



Lt.-Col. Colby

THE SAVANA OF CENTRAL AFRICA.

This picture shows one of the many varieties of savana country. Notice the parklike aspect of the region.

sheep, horses, etc., by Europeans. The native peoples of the Australian savana are the "Black fellows," a primitive group comparable in development to the Bushmen of the Kalahari Desert.

None of the savana areas is highly developed as yet, but they hold great promise for the future. As they are never cold, crops can be grown all the year round, hence they should, in the future, yield temperate crops in the winter season with irrigation, if necessary, and tropical crops during the summer season. Thus they have great possibilities for the extension of cotton cultivation, and the production of tobacco is steadily increasing in Rhodesia.

HOT, EAST COAST TYPES—A. MONSOON OR INDIAN TYPE

The hot east coast lands (Fig. 130) fall naturally into two groups:—

(*a*) Monsoon or Indian type;
(*b*) Trade Wind or Caribbean type.

Climate

In the true monsoon lands (*i.e.* Indian type) the winds are seasonal. Wet on-shore winds (*i.e.* winds from the sea) are prevalent in summer, and dry off-shore winds (*i.e.* from the land) blow in winter. The winds of India are therefore south-west in summer and north-east in winter.

True monsoon lands are very hot in summer (approximately 80° F. to 90° F.), and warm to hot in winter. The rain falls in summer when the winds are blowing on-shore, but the total annual rainfall varies according to the locality, being heaviest where the mountains are favourably situated in relation to the direction of the prevailing winds, *e.g.* on the W. Ghats and in Burma and Assam. But in North-West India there is an arid zone (the Thar Desert) with less than 10 in. of rain annually. In true monsoon areas the year can be divided into three seasons:—

(1) October to March, the cool, dry season.
(2) March to June, the hot, dry season.
(3) June to October, the hot, wet season.

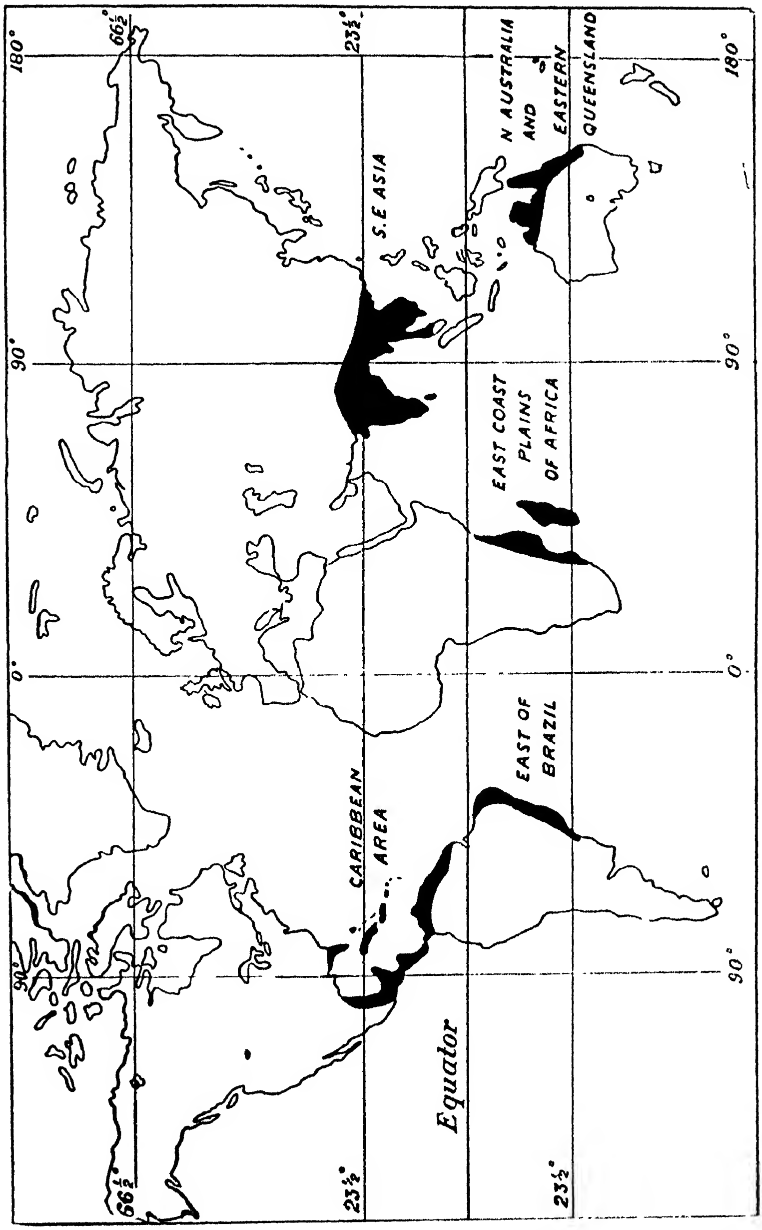


FIG. 130. MONSOON REGIONS AND HOT EAST COAST REGIONS.

The rains come very suddenly, and there is then a drop in temperature similar to that noted in the savana areas. Thus the hottest month is usually April or May in the northern hemisphere. These divisions of the year can be worked out by a study of Fig. 131.

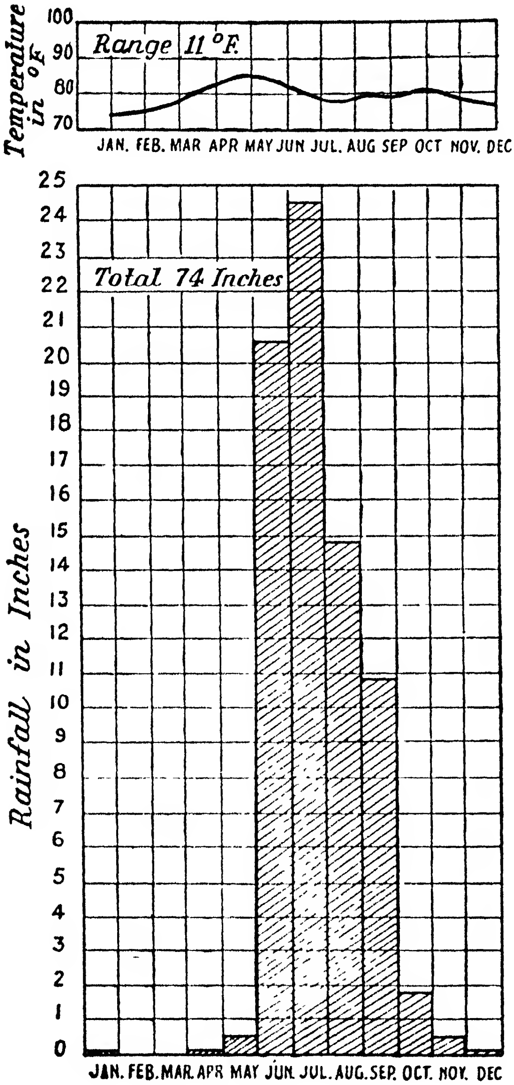


Fig. 131. Monsoon Type. Bombay (37 ft.).

The rainfall of the districts around Madras comes in the late autumn and winter, under the influence of the north-east wind which has crossed the Bay of Bengal. There are really only two true monsoon areas in the world, viz. S.E. Asia and North Australia, though East Africa receives the "fringes" of the Indian Ocean monsoon system. The Asiatic and Australian monsoons are complementary to one another. In July (winter in Australia) a dry land (S.E.) wind blows off-shore, and crossing the equator becomes a wet S.W. wind blowing on-shore in Asia (where July is a summer month). In January (Asiatic winter) a dry land wind (N.E.) blows off-shore, and crossing the equator becomes a wet N.W. wind blowing on-shore in Northern Australia [where January is a summer month (see Fig. 105)].

Vegetation

The vegetation of the monsoon areas varies with the amount of rainfall. Where the rain is very heavy (over 80 in.) there are " rain forests " which are always green; heavy rain (40 to 80 in.) produces a rich, deciduous forest (teak, etc.), which sheds its leaves in the dry, hot season; moderate rainfall only supports a kind of grassland and thorn scrub, while in areas of deficient rain there is desert, *e.g.* the Thar Desert.

HOT, EAST COAST TYPES—B. TRADE WIND OR CARIBBEAN TYPE

Climate

There are, however, other regions in the world, where the temperature and rainfall conditions are very similar to those of monsoon areas. The winter temperatures are 70° F. or over and the summer temperatures over 80° F. (Kingston, Jamaica, Jan. 75° F., July 82° F.). The rainfall is over 40 in., but its yearly distribution differs from that of the true monsoon areas. Instead of there being definite wet and dry seasons as in India, the rainfall is more evenly distributed throughout the year, though in all cases there is a pronounced summer maximum. This is because the winds are not seasonal as in true monsoon areas, but the trade winds blow on-shore all the year round. They blow most directly on-shore and are strongest in the summer months, hence the increase in the summer rainfall. Trade winds pick up moisture greedily as they cross the warm oceans, and thus when they reach high land and are forced to rise, they cause heavy rainfall.

Vegetation

Because the temperatures and total rainfall of the Caribbean type are so similar to those of the monsoon areas, the natural vegetation is a luxuriant forest, comparable with the forests of South-East Asia. When cultivated, both types of region yield similar products.

Development

In regions of the monsoon or Caribbean types where the original forest still remains uncleared the lumbering of hardwoods is of some importance. Teak is the most noted timber

of South-East Asia, especially in Burma and Siam. Transport of the logs is not as easy as it is in the temperate regions where the ground is frozen in winter, hence elephants are used for hauling the timber.

Where the forests have been cleared, the people are engaged in tropical agriculture, growing some of the following crops:—rice, millet, cotton, coffee, jute, sugar, hemp, bananas, pine-apples, etc.

The high temperatures, heavy rainfall, and humid atmosphere make white labour impossible in the hot east coast regions. Hence their development is dependent on coloured peoples who can work in such climates, and white people are generally engaged in the work of organisation. The Hindu and Chinese immigrants of East Africa, the Negro immigrants of the West Indies, and Hindus in British Guiana make agricultural development possible in the areas named. In some regions such as South-Eastern Brazil, the people of South Europe, viz. Italians and Spaniards, work on the plantations.

Tropical agriculture reaches its most advanced stage in South-Eastern Asia. The land is cultivated so carefully and with such diligence that the small " farms " (often not more than two acres) are highly productive. No land is wasted, and the hill sides are terraced to provide more available farm land. The methods used are more like those of gardening than farming, hence the frequent application of the term " horticulture " or "spade agriculture " to the type of cultivation practised in monsoon lands. Because of this intensive culture and the growth of more than one crop per annum, the plains of South-East Asia support an extremely dense population.

In all the other regions of the hot east coast type (except Northern Australia), the development of plantations by Europeans for the large-scale production of crops is carried on side by side with native agriculture. The degree of progress depends largely on the available labour supply.

Thus in the West Indies, where there is negro labour, plantations are extensive, but in North Australia, where coloured labour is excluded, the land is still undeveloped. There is little industrial development, and the main function of these regions, at present, is (1) to yield supplies of foodstuffs

mahogany, rosewood, ironwood, greenheart, and the rubber and cacao trees.

The true selva has a closely interlocked canopy formed by the crowns of the trees. This shuts out the light from the lower part of the forest, which is, as a result, dark, damp, and gloomy, with little undergrowth. Giant lianas or vines

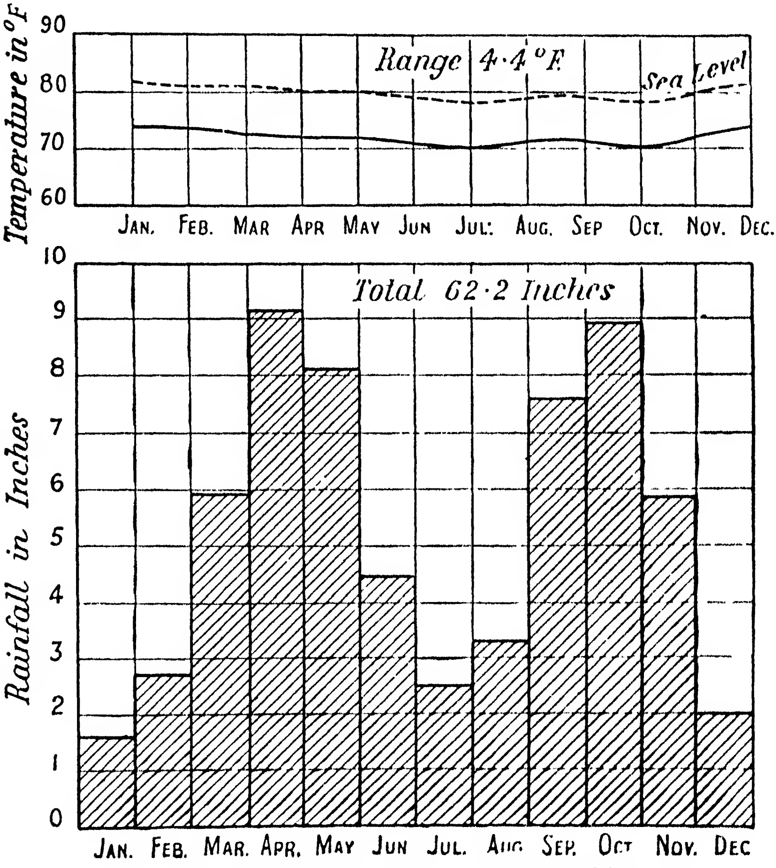


Fig. 133. EQUATORIAL TYPE. YAUNDE (2461 FT.).

twine from tree to tree, and some hang from the branches and coil in great tangles on the ground. Where the forest canopy is less compact and sunlight can penetrate, dense undergrowth develops. Many of the animals of this forest live most of their lives in the trees. These forest areas are not easy to clear, and when cleared, weeds and small bushes grow with amazing rapidity.

Development

As these are forested regions, it would not be unreasonable to expect that the successive stages of development would be similar to those of the forest regions of the temperate zone, viz. hunting, lumbering, agriculture, and industry. But owing to the nature of the forests, the type of wood, and the climatic conditions, these stages of development have not occurred, and the forest has only been cleared for cultivation in the most favourable and most accessible districts.

The animals of the hot forests, though many and varied, are not fur-bearing, since they do not have to withstand the cold temperatures of the northern winters. Hence trapping has never been important, though native tribes hunt some of these animals for their flesh.

Extensive lumbering operations comparable to those of the temperate forests have been impossible for a number of reasons:—

(*a*) There are no cold winters and no heavy snow-fall to provide a frozen surface over which the logs can be hauled easily.

(*b*) The ground is soft and wet, and transport correspondingly difficult.

(*c*) Although there are numerous large rivers on which logs can be floated, many of the woods of the equatorial forests are heavier than water, and have to be transported by boat.

(*d*) The trees do not grow in "stands," and the work of finding and then extricating the suitable trees is laborious and expensive.

(*e*) Although many of the trees yield valuable and beautiful timber, highly prized for cabinet work, there is not as large a demand for these woods as for the softer and more easily worked timber of the temperate forests. For this latter reason one often finds a settler in the Amazon valley using imported North American timber for building purposes, in spite of the fact that forests are growing all around him. Lumbering is a very heavy form of manual labour, and therefore is an unsuitable occupation for white people in hot, damp climates. The native peoples are generally few in number, and are not adapted to organised work such as lumbering entails.

CHAPTER XVII

PRIMITIVE COMMUNITIES

Introductory

The preceding chapters on Natural Regions have shown that all parts of the world, even those with similar conditions of climate and vegetation, have not reached the same stage of development. The more civilised man has become, the more he is able to utilise and develop the natural resources of the region in which he lives. But man is no longer limited to the same extent by his environment. He can overcome many natural disadvantages such as the lack of water by irrigation schemes, marshy land by drainage, and the prevalence of disease by medical knowledge, etc. He no longer relies entirely on local supplies of food and raw materials, but, through the development of trade and commerce, has access to the vast resources of the whole world.

There are still, however, immense areas which are undeveloped and where the inhabitants are almost entirely dependent on local resources. The peoples of these regions are often referred to as " Primitive Peoples."

The best known examples of such communities are to be found in the cold deserts, the Asiatic steppes, the hot deserts, the savana lands, and the equatorial forest areas.

The Cold Deserts

The two extensive regions of cold deserts are the tundra of Eurasia and the " Barren Lands " of North America.

THE TUNDRA OF EURASIA.—The chief groups of people inhabiting the Eurasian tundra are the Lapps, Samoyeds, and Yakuts.

The natural resources of these lands include the wild animals, birds, fish, and a variety of berries which ripen during the short summer. The vegetation consists of lichens, mosses, and berry-bearing bushes. Trees are limited to stunted birch and willow found along the water-courses. Animal life includes the Arctic fox, the Arctic hare, the lemming (a small

mouse-like animal), the ptarmigan and other edible birds, and the seals and walrus of the coastal regions. By far the most important animal is, however, the reindeer, which has been domesticated and which constitutes the chief source of wealth, and provides most of the necessities of life.

Because of the low temperatures, short summers, and frozen soil agriculture is impossible, and the natural occupations are hunting, fishing, and herding.

The food of these peoples consists of flesh (often raw or decomposed), reindeer milk, and fish and berries, both of which are eaten fresh during the summer, but are also dried for winter use. By bartering furs and skins they sometimes obtain such luxuries as tea, coffee, and tobacco.

In these cold regions warm clothing is necessary, and is made from the skins of wild animals and reindeer. These skins are cured and made into garments by the women, who use bone needles and sinews for thread. Both men and women wear furry hoods over their heads, fur gloves, and long fur-lined boots.

As the reindeer, which live on mosses and lichens, must be constantly moved to new feeding grounds, the life is nomadic, and permanent homes are of little use. The tundra dwellers therefore live in tents (chooms) composed of a wooden framework over which are stretched reindeer and other skins. These can be easily transported from place to place. The floor of the tent is often carpeted with dry moss, but the only " furniture " consists of reindeer skins for beds, a cooking pot, and crude lamps in which seal oil is used for lighting during the long dark winter. Their other possessions include axes and bows and arrows for hunting, though the use of firearms is increasing. For transport they use sledges, usually drawn by reindeer, and skis.

In the southern hemisphere the Onas of Tierra del Fuego live in a rather similar environment, and though of an entirely different race, have very much the same mode of life, depending for most of their necessities on the guanaco, an animal similar to the llama of the Andes.

THE " BARREN LANDS " OF N. AMERICA.—The Arctic regions of N. America and the coastal fringes of Greenland are inhabited by Eskimos.

The natural resources are almost identical to those of the Eurasian tundra, with one important exception, viz. that the place of the domesticated reindeer is taken by the undomesticated caribou.

Therefore the Eskimos are engaged almost exclusively in hunting and fishing, except where, in recent years, herds of reindeer have been introduced. Many of the Eskimo tribes

Mondiale

LAPPS AT HOME IN SUMMER.

The trees are birch trees, which grow further north than the conifers. Note the crude nature of their portable dwelling; the skin coat with a fur collar worn by the boy in the centre; the metal bucket and the man's pipe, evidences of contact with more advanced peoples; and the Mongolian features of some of these people.

are entirely dependent on sea fishing and the hunting of whales, seals, and walrus. Even during the winter they will sit patiently for hours by a hole in the ice ready to spear fish with their harpoons. They eat fish and large quantities of fat or blubber in order to resist the cold. Vegetable food plays little part in their diet.

Their clothing consists of warm furry skin garments, *e.g.* seal skins and the skins of polar bears. For the winter they

build snow huts (igloos) with windows of fresh-water ice, but in summer when the snow melts, their dwellings are tents made of driftwood and deerskins.

The summer, with its continuous daylight, is a period of activity, for then the caribou of the forest move north, and provide fresh quarry for the Eskimo hunter, while fish must be caught and dried, and blubber stored for winter use.

For transport they use canoes (kayaks), large boats (umiyaks) in which the whole family can travel, and sledges drawn by teams of sturdy dogs.

Most of their possessions such as harpoons, bows and arrows, sledges, etc., are fashioned from driftwood, whalebone, skins, and fishbones. In spite of their hardiness and ingenuity the Eskimos are barely able to maintain a livelihood, and their numbers are decreasing.

The Coniferous Forest

South of the cold deserts a wide belt of forest extends from west to east across N. America and Eurasia. The Ostiaks and Tunguses live in the Asiatic forest, and in former times the Red Indians, most of whom now live in government reserves, inhabited the American forest.

Because of the continuous tree covering, both agriculture and herding are equally impossible, and the forest peoples are primarily hunters and fishers. The forests of fir, pine, spruce, and larch provide little in the way of vegetable food, but the rivers teem with fish, and the forest with deer and small fur-bearing animals (*e.g.* beaver, skunk, marten, squirrel, etc.).

Like their neighbours to the north, the forest peoples wear warm, furry clothing, and live in skin tents which are usually pitched in a small clearing near a river, where the river fish and the forest animals are within easy reach. Because of the obvious difficulties of forest travel the chief means of transport is by canoe along the rivers. Contact with the white man has led to fur trading as an additional means of livelihood.

The Peoples of the Temperate Grasslands

The Kirghiz of Central Asia are an example of people adapted to a grassland environment. The one natural resource of the steppes is grass. There are few trees except for willows

along the watercourses. Over large areas the rainfall is scanty and unreliable so that agriculture is undeveloped.

The Kirghiz are pastoral nomads who move from pasture to pasture with their flocks and herds of horses, camels, oxen,

Mondiale

KIRGHIZ.

Here is a typical example of a dweller on the Asiatic steppes. Note the type of clothing he wears. Behind him stands a yurt or felt tent which can be readily transported from place to place.

sheep, and goats. Although these people are so dependent on animals, meat forms only a small portion of their food. The herds are often depleted by blizzards and the attacks of wild animals (*e.g.* wolves); young animals must be kept to

replenish the stock, while some are bartered for firearms, cotton cloth, tea, and flour. Cheese and milk, the latter often sour or fermented (*e.g.* koumiss), are the chief articles of diet. Vegetable food is scarce, and flat unleavened loaves, baked on hot stones, are a luxury. Owing to the scarcity of wood, the dried dung of animals is used as fuel for cooking.

Camel's hair cloth, leather, sheepskins, and cotton fabrics are used for clothing, sheepskin hats, coats, and long boots being characteristic articles of attire.

As in other nomadic communities the homes are portable tents (yurts). These are constructed of a circular willow trellis, covered with layers of felt made from the wool of the animals. The encampments are usually circular in form. During the summer many of the Kirghiz tribes migrate to the high, well-watered, rich grassy valleys of the neighbouring plateaux, where their dwellings are sometimes of a more permanent character, being built of stone.

The tents are richly furnished with rugs and carpets worked in beautiful patterns by the Kirghiz women. Most of their household goods are made of leather (*e.g.* bottles for carrying milk) or sometimes of wood, for fragile articles would not stand the constant moving. The men fashion beautiful harness of leather.

The Kirghiz are fearless horsemen, and even young children are expert riders. As with other nomadic peoples, the women do most of the routine work, *i.e.* milking the animals and pitching camp. To the men fall the tasks demanding great spurts of energy and courage, *i.e.* the rounding up of straying herds, the repulse of wild animals, and the long hunting excursions in quest of game. They often return exhausted, and will rest, apparently indolent and lazy, for days.

Although living in Russian territory, the Kirghiz are a law unto themselves, the ruling of the oldest member of the tribe (the patriarch) being final in all disputes.

In recent years the Russian government, by extending its agricultural policy, has brought much of the former Kirghiz pastures under the plough, and is trying to convert the nomadic pastoralist into a settled agriculturalist.

In the North American prairies the Red Indian has virtually disappeared. He was never a herder like the Kirghiz, for the native animals, such as the bison, were not domesticated

Neither was the " gaucho " of the pampas a herdsman, because the South American grasslands were originally the home, not of hoofed animals, but of large rodents such as the chinchilla, viscacha, and capybara. The same is true of Australia, where the only important animals of the grasslands were marsupials such as the kangaroo. In South Africa, however, there are many black tribes who follow a mode of life similar to that of the Kirghiz. The Hottentots, for instance, depend largely on herds of oxen, live mainly on milk, and use the hides of their cattle for making cloaks, shields, etc.

The Peoples of the Hot Deserts

As noted in an earlier chapter the desert dwellers vary very much in type.

(1) Some live in permanent settlements in the oases and are both cultivators and herdsmen. They grow crops of rice, maize, fruits, onions, and tomatoes, and on the drier edges of the oases rear sheep, goats, and camels. Their diet is varied, and includes the all important date, mutton, fruits, grain, and vegetables. They live in flat-roofed houses made of sun-baked mud or stone. The oasis-dwellers are highly organised, and where trading brings them into periodic contact with the outside world, often reach a high cultural level. The peoples of the Saharan oases are of the type described above.

(2) Other desert-dwellers such as the Bedouins of Arabia and the Tuaregs of the Sahara are entirely nomadic. The driest portions of the desert have not even the scantiest vegetation suitable for grazing, but where the rainfall approaches 10 in. annually dry scrub and coarse grass is found. Here the nomads rear sheep, goats, and camels, wandering from pasture to pasture with their tents. The camel is invaluable, for it not only provides milk, but because of its speed and its ability to go without food or water for several days it is specially suitable for desert transport. The usual attire of the desert nomads consists of long flowing robes of white cotton cloth.

They are virile and courageous, but prone to acts of brigandage, plundering both oases and trading caravans to acquire food and other necessities in times of scarcity.

(3) In the Kalahari Desert live the Bushmen. These people are probably the descendants of the earliest inhabitants of Africa. Because of their isolation and the scanty resources of their environment, they rank among the most uncivilised and backward peoples in the world, comparable in many ways to the Australian " Black fellows."

Domestic animals and agriculture are unknown to them, but they are expert hunters, nimble, and fleet of foot. It is said that they can imitate the calls of every wild animal they know, and can approach within a few feet of the most timid animals to hurl their poison-tipped reed arrows. In fact, their inherent knowledge of nature and of the sources of natural poisons is probably unsurpassed by that of any other people.

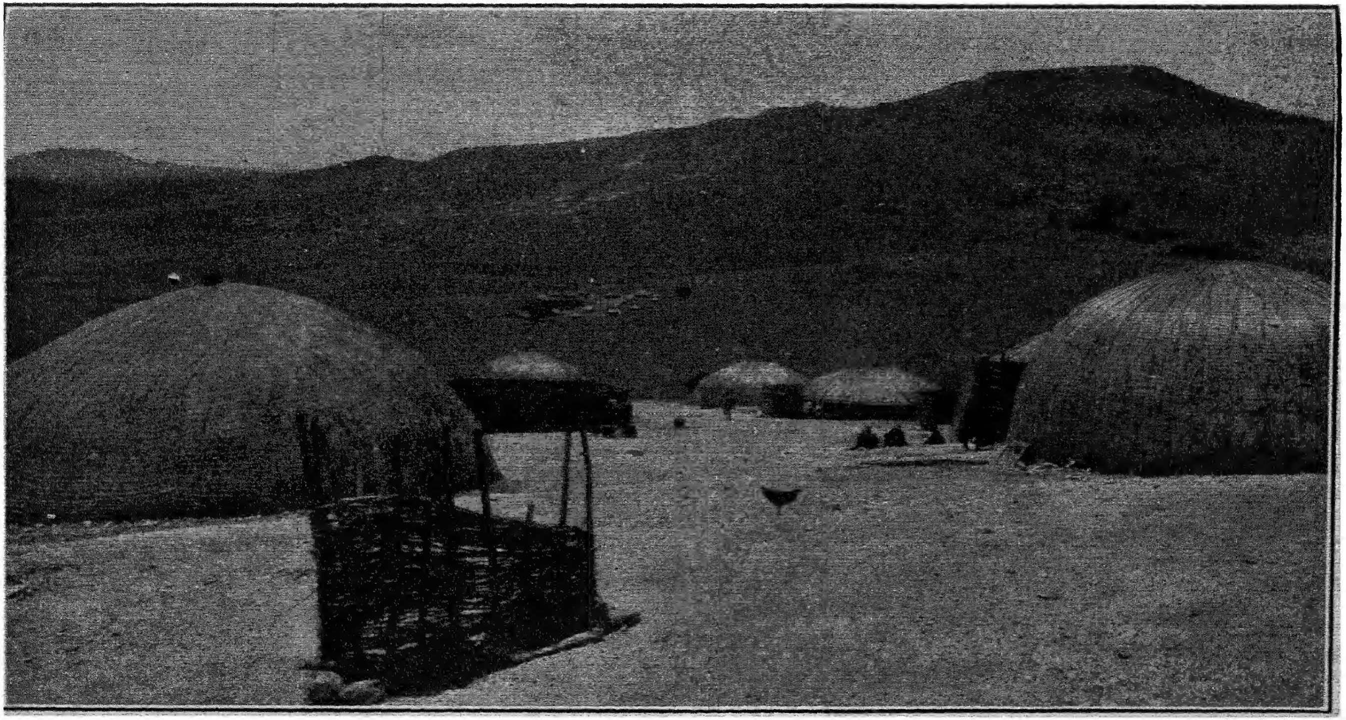
Their food consists almost entirely of meat, often raw or decomposed, and in times of scarcity they will eat insects, snakes, and anything else they can obtain. They also dig for edible roots with primitive digging sticks. Because it is rarely cold they wear little clothing, usually a skin loin-cloth or a skin cloak (kaross). Their homes are extremely crude, and often consist of mats of plaited reeds hung in front of a rocky recess or cave. Their most precious commodity is water, stores of which they hide beneath the sand.

Unlike the people who depend on domesticated animals, the Bushmen do not live in tribes but in small family groups, for otherwise there would be too many people in one place for the scanty supplies of game. They have great powers of endurance, and are patient, hardy, virile, and courageous. In times of scarcity, like other nomads, they often plunder the herds of neighbouring tribes.

The Peoples of the Savana

In the savana, as in the desert, the native peoples differ in their response to their environment. Three stages of cultural development may be distinguished:—(1) pastoral peoples; (2) those who combine pastoralism with primitive agriculture; (3) agriculturalists.

(1) The Masai of the East African plateau are an example of pastoral peoples. They are a tall, strong, warlike race, partly negroid in type. They rear herds of cattle, sheep, and



South African Railways & Harbours

KRAAL SCENE IN ZULULAND.

Note the openness of the country, the grassy slopes and the scarcity of trees. The kraals, composed of groups of bee-hive shaped huts and enclosures for animals, are scattered over the countryside and are not connected by roads.

goats on the grasslands, but since the savana grasslands are richer than those of the steppes, their life is less nomadic than that of the Kirghiz. They eat little meat, their diet being almost entirely confined to milk and blood. In spite of the existence of a large variety of wild animals (antelope, gazelles, etc.) the Masai confine their hunting activities to the pursuit of the lion, the natural enemy of their herds. In lion hunting they show a degree of courage and daring which is almost unsurpassed. Because of the high temperature they wear little clothing. Their circular huts are composed of a framework of branches over which is smeared mud and animal dung. A group of such huts is enclosed by a circular thorn thicket within which the cattle are driven at night. In their wanderings the Masai come into conflict with the more settled peoples whose crops and stores they raid.

A Masai reserve has been established in Southern Kenya, but unfortunately much of this territory was too arid for cattle rearing, and so was disastrous for the Masai. The reserve has now been extended to include some of the richer grasslands.

(2) The Kikuyu are a race of Bantu negroes who live to the north of Mount Kenya. These people combine agriculture with pastoralism. They not only rear cattle, but cultivate small plots of banana, manioc, and millet. Their homes and clothing are similar to those of the Masai, but their diet is more varied. They lead a more settled life, and are less warlike in disposition.

(3) The Hausas, a race of Sudanese negroes, live in the savana lands of West Africa, south of the Sahara. They are essentially a settled agricultural people, but their methods of farming are primitive. Until the period of colonisation by the white man, the Hausas did not use ploughs, but, as many still do, broke up the surface soil with hoes and digging sticks. On the crudely cultivated patches of land they grow cotton, millet, guinea corn, and ground nuts. Formerly they did not rear cattle because of the raiding propensities of their neighbours, the Fulani. Under the more peaceful conditions of European government, and because they now realise the agricultural value of animal manure, they rear large numbers of long-horned cattle.

supply is more certain and varied. Like them, however, they wear few clothes, and build square, pointed, thatched huts which are usually placed along the edges of the forest clearing. Because of the danger from wild animals, and for other reasons, these houses are often raised on stakes, several feet above the ground level.

The primitive agriculturalists are generally of a peaceful and somewhat indolent type. Nature is so lavish in the equatorial regions that a minimum of work will provide an ample food supply. There is no season when food is short, and the storage of supplies for future use is unnecessary. Consequently there is no incentive to steady work and progress, and such peoples are of little value for plantation work.

CHAPTER XVIII

THE CEREALS

Distribution of Products

Rubber would not flourish in England, nor the olive in the Amazon basin. For each important plant product there are certain conditions under which it thrives best. In this chapter the distribution of, and the conditions for the successful cultivation of the chief products, both food and raw materials, will be outlined.

Wheat

Wheat is the most important of all the cereals, and has been cultivated for several thousand years. Wheat grains have been found in the Stone Age lake dwellings of Switzerland. Scientists believe they have discovered in Palestine the wild cereal from which the cultivated varieties of wheat have been evolved.

CONDITIONS OF GROWTH.—There are many varieties of wheat adapted to special conditions of soil and climate, but in general the following conditions are necessary for wheat cultivation:—

(1) A moderate rainfall, *i.e.* about 20 in. to 30 in., some of which must fall in the growing season.

(2) A period of warm, sunny weather for ripening.

(3) A light, clayey soil.

(4) Land flat enough for the use of modern machinery on a large scale, but at the same time sufficiently undulating to be well drained.

The climate of Mediterranean regions satisfies these conditions, and so does that of the central areas of continents in the temperate zone. In the latter the rain comes mainly in the summer, and falls in the growing period of the early summer months. The late summer months, when the grain ripens, are dry. In Northern India the heavy rains of summer are followed by winters sufficiently warm to ripen the grain.

Hence wheat can be sown at the end of the monsoon rains and harvested in the winter months.

Areas of Production (Fig. 134).—The principal wheat-growing countries of the world may be divided into three groups:—

(1) The densely-populated countries of Western Europe, viz. Britain, France, Belgium, Holland, Denmark, Germany, etc. Because of the high price of land and the relatively dense population, farmers cultivate the land intensively, in order to obtain a high yield (30-50 bushels per acre). Even with this yield the amount of wheat produced (except in

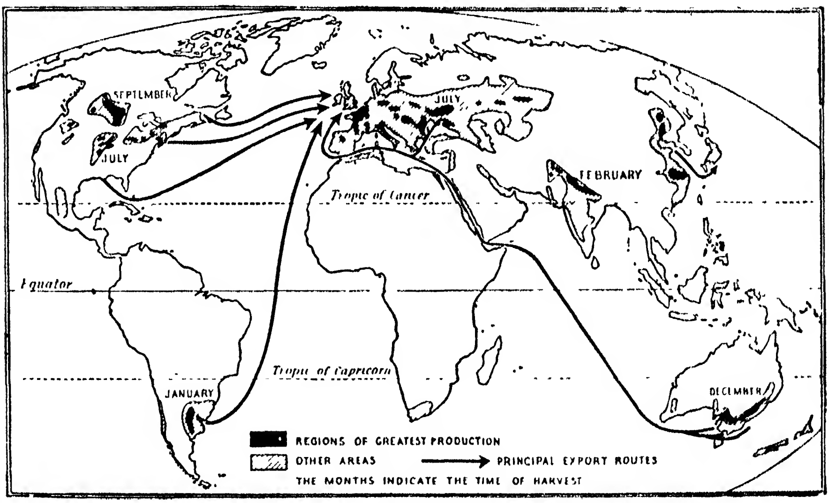


Fig. 134. Distribution of Wheat Production.

France) is not sufficient to supply the needs of the people, and wheat has to be imported. Britain grows only 20 per cent. of her requirements.

(2) The more backward and less densely populated countries of Eastern and South-Eastern Europe. In these lands wheat is grown by small peasant farmers primarily to satisfy their own needs. The methods of production are not scientific, and the yield is much lower. In Russia before the War (1914-18) the yield was only 8 bushels per acre, but Russian wheat production has undergone great changes in recent years. In spite of the low yield, countries with extensive

fertile plains, such as Roumania and Hungary, have a considerable surplus for export.

(3) The "new" lands, such as Canada, Argentina, Australia, and Central United States, where cultivation is of the extensive type on farms of very large area. The yield averages rather less than 20 bushels per acre, but the vast areas under cultivation and the small home consumption make large quantities available for export to the densely-peopled areas of Western Europe.

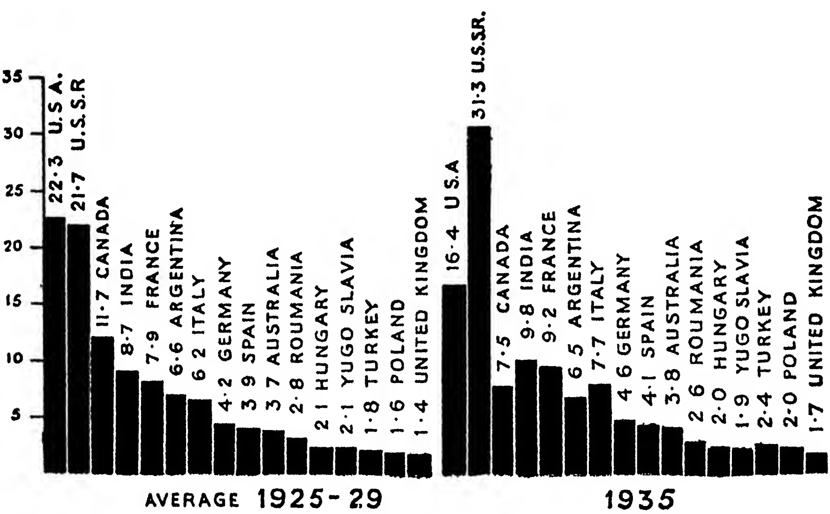
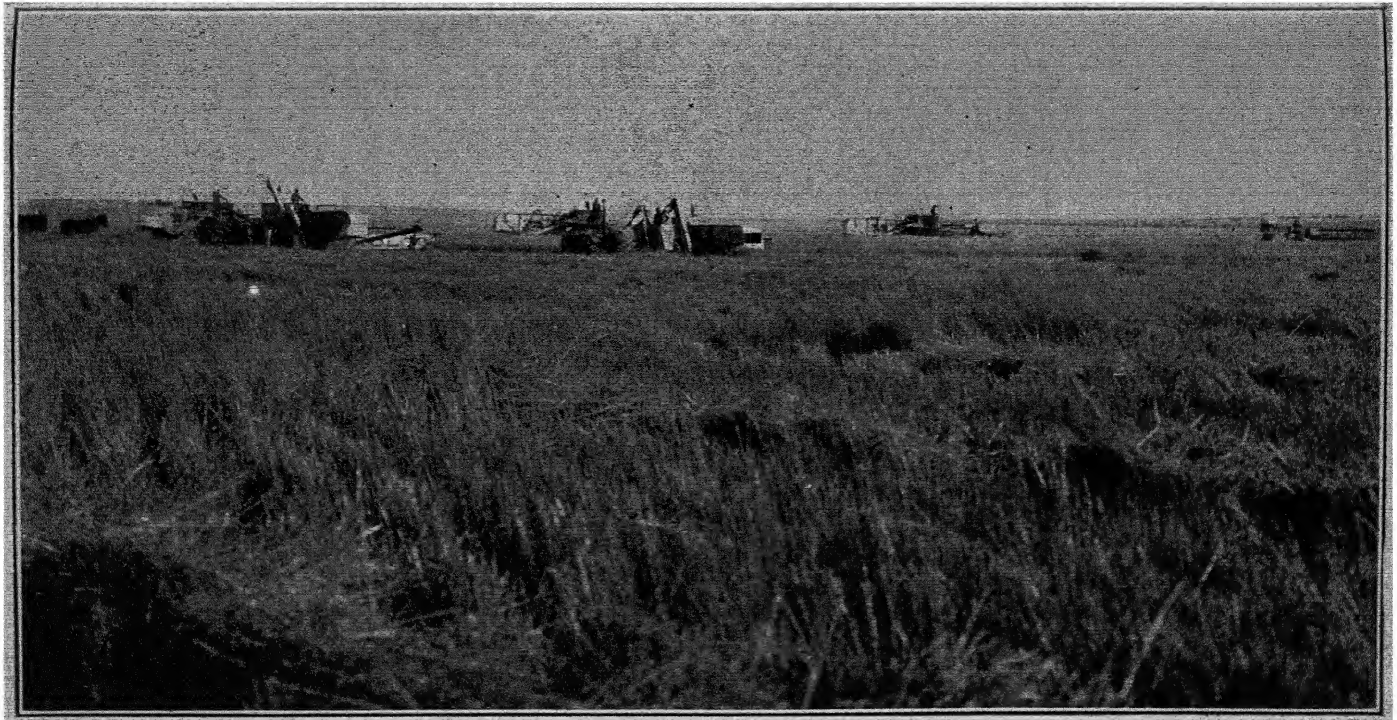


Fig. 135. Production of Wheat in Millions of Tons to Approximate Figures.

Recent Changes.—Before 1914 Russia (U.S.S.R.) was an important producer of wheat, but political and financial difficulties caused a very rapid decline in her wheat production. In 1927 (as shown by the accompanying tables) Russia had so increased her output as a result of agricultural reorganisation, that she had risen to the position of second world producer. Now the U.S.S.R. is the leading producer, with twice the annual amount of the U.S.A., which is second on the list. The Russian wheat lands are in S. European Russia (the Black Earth Lands) and in the northern half of the steppe lands of Siberia.

Other facts shown by the diagrams (Fig. 135) are (1) the increase in production in France, Italy, and India; (2) the position



Canadian Pacific Railway

WHEAT HARVESTING.

Here is a typical scene in the prairies of Saskatchewan. Note their vastness, and the reason for using machines which not only cut the wheat but also thresh it. These machines permit the wheat to be produced much more cheaply in the " new " countries.

of France, one of the densely populated countries of Western Europe, as fourth world producer. The most striking fact is the great decrease in the wheat output of Canada and the United States. The real cause of this decrease dates back to 1914 when Russian supplies were cut off and prices rose. Canada and U.S.A., encouraged by high prices, increased their wheat acreage to meet European demands. The bumper American crops of 1928 and 1929 resulted in low prices with which European farmers could not compete, so that the governments had to safeguard their wheat farmers (*e.g.* British wheat subsidy). Under this protection European wheat production increased, and at the same time Russian supplies became plentiful, so that imports from the " new " countries dropped. The continued rise in production and consequent low prices and smaller markets made it impossible for American farmers to dispose of their harvest, and in 1932 large quantities had to be burned, and American wheat farmers began to cultivate other crops. The Americans claim that the European importing countries are to blame because production has been increased by tariffs and subsidies.

How can this problem of wheat production be solved? Should the " new " countries of extensive and cheap wheat production supply the world's needs, and the importing countries of dearer production use their land for other types of farming? Remember that the U.S.S.R. is the only European country which, by virtue of cheap land and vast areas, can adopt American large-scale methods of production.

European imports of wheat are, from Canada 35 per cent.; Argentina 20 per cent.; U.S.A. 20 per cent.; Australia 15 per cent.

Maize

Maize, or Indian corn, was originally grown in America, whence its cultivation has spread to most of the countries of the old world. The grain is used as human food in Mexico, Italy, and many of the S. American countries; in N. America and Europe it is primarily used for feeding animals. The dried leaves and stems are used for paper making, and in parts of America, viz. the lower St. Lawrence valley, the young green shoots are stored in silos for the winter feeding of cattle.

Agent-General for Queensland

MAIZE GROWING IN QUEENSLAND.

Notice the height of the plants. More rain and heat are required to grow maize than wheat. In countries where it is too cool for the grain to ripen maize is sometimes grown as a fodder crop.

REQUIREMENTS.—(*a*) A five months' growing season, the mean summer temperature being above 66° F.

(*b*) Summer rainfall to maintain plant growth.

(*c*) Deep, warm, and rich well-watered soils.

From the above conditions it is clear that maize will not ripen in lands with cool summers such as England; nor will it grow in lands with " Mediterranean " conditions of scanty summer rainfall. Although it likes heat, it does not yield so well in very hot and wet countries.

CHIEF PRODUCING AREAS (Fig. 136).—(1) The " Corn Belt " of the United States, *i.e.* the central states of U.S.A. between

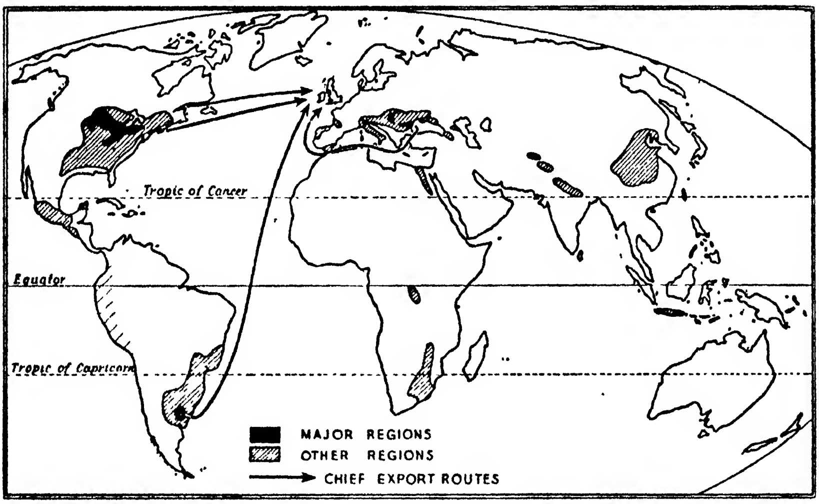


Fig. 136. DISTRIBUTION OF MAIZE PRODUCTION.

the Canadian border and the latitude of St. Louis. The bulk of the maize of this region is used for feeding animals (cattle and pigs) as at Chicago, St. Louis, Omaha, Kansas, etc. Thus maize is the basis of the American meat packing, bacon curing, and allied industries.

(2) Some maize is grown in the southern states of the United States, *i.e.* in the Cotton Belt. Much of this crop is used for food by the negroes.

(3) Maize is grown on the wetter pampas between the Parana and Uruguay rivers in Argentina.

(4) All the states of Central America and the Andean states of S. America grow maize for use as native food. There is no export from these states.

(5) The Danube lands and South Russia are the principal producers of maize in Europe, and some is exported from Roumania and Hungary to Western Europe.

(6) In some parts of the Mediterranean countries, viz. the northern plains of Italy, where the summers are not too dry, or where irrigation can be practised, maize is grown and used for food by the peasant population.

(7) China, India, South Africa also grow maize for home consumption.

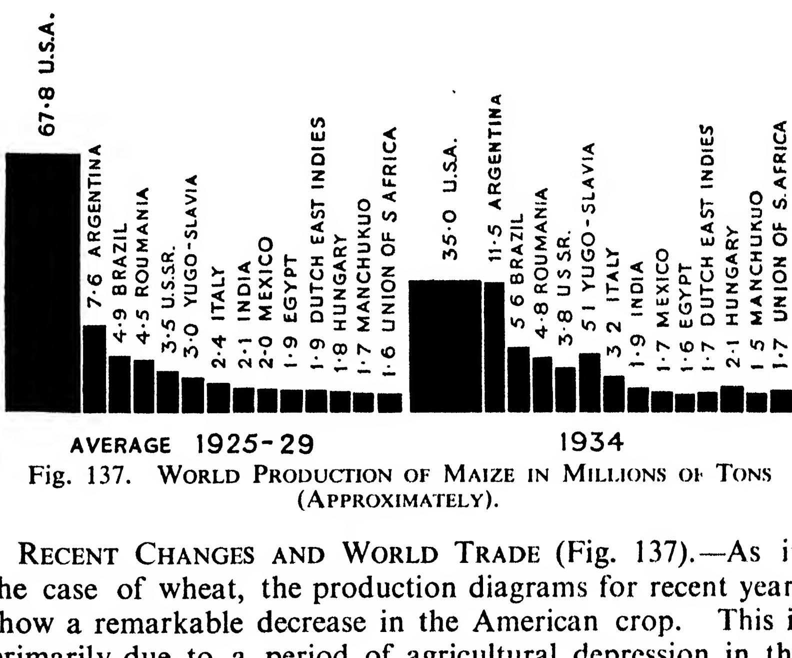
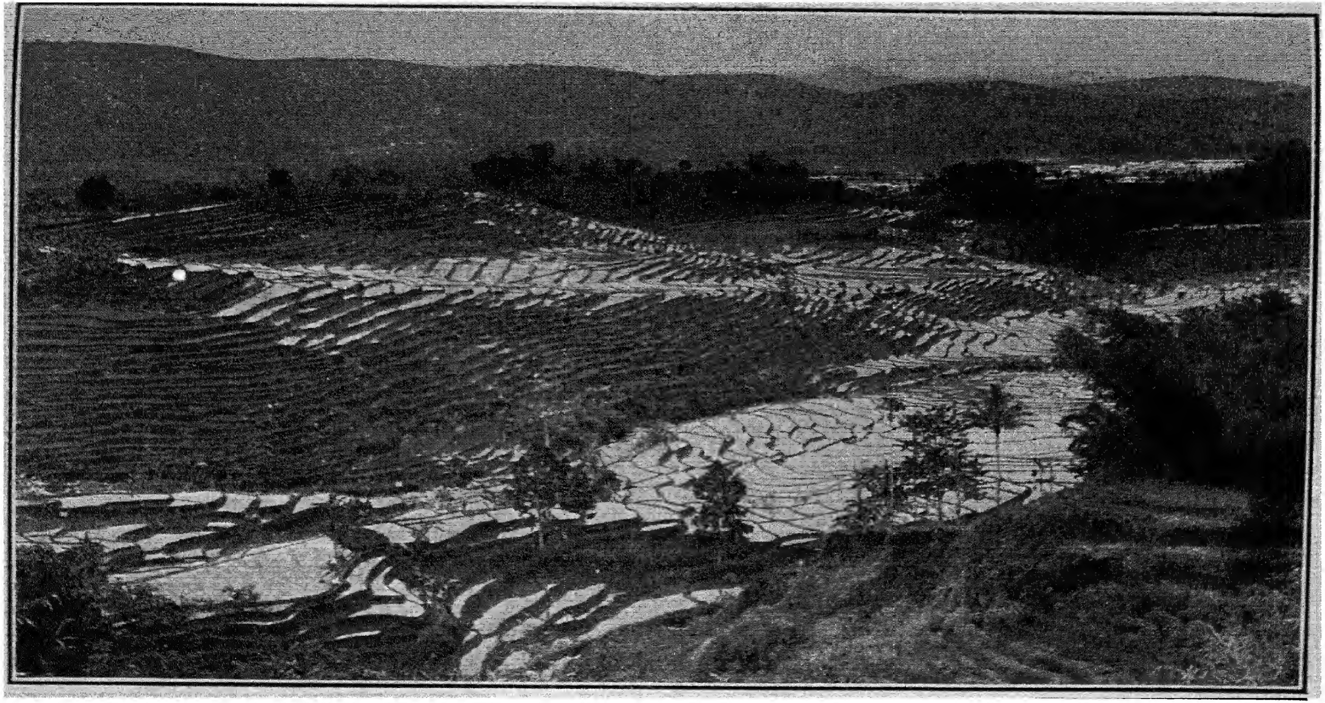


Fig. 137. WORLD PRODUCTION OF MAIZE IN MILLIONS OF TONS (APPROXIMATELY).

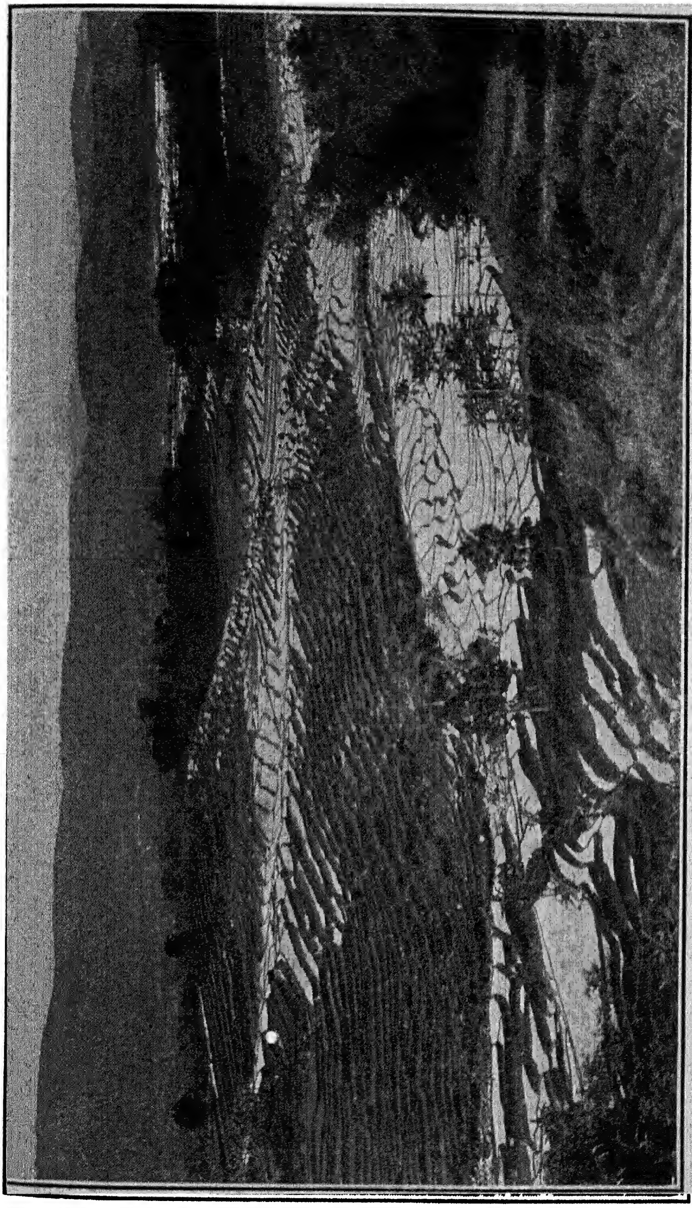
RECENT CHANGES AND WORLD TRADE (Fig. 137).—As in the case of wheat, the production diagrams for recent years show a remarkable decrease in the American crop. This is primarily due to a period of agricultural depression in the United States and the yield will probably rise again with the return of prosperity. The most noteworthy increases in recent years were in Brazil, Yugo-Slavia, and Russia (the latter being due to the agricultural development under the Five Year Plan). Although Argentina produces so much less maize than the United States the former country is the leading world exporter. In fact, the United States hardly exports any of the maize crop, and often imports from Argentina. The possibility of



Netherlands Chamber of Commerce

RICE GROWING IN JAVA.

Here is an example of intensive cultivation in which an enormous amount of cheap hand labour is employed. Compare this with wheat growing in Canada. The terracing not only enables the rice to be flooded during the early stages of its growth, but extends cultivation from the plains and valley bottoms to the hills.



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CHAPTER XIX

OTHER FOOD PRODUCTS

Tea

Tea is the dried leaf of a shrub native to S.E. Asia.

REQUIREMENTS.—(1) Warm summers of tropical and subtropical lands, but a certain amount of frost is not injurious.

(2) Abundant rainfall.

(3) Good drainage, therefore it thrives best on hill slopes.

(4) Abundant supplies of cheap and skilled labour necessitated by the amount of work entailed in picking, drying, and packing the tea. Female labour is used because of the care needed in plucking the leaves from the shrub.

CULTIVATION AND PREPARATION.—For the establishment of a new tea-garden a plot of land is cleared and seedlings about one foot high are transplanted four feet apart. When they are three years old the bushes are ready for picking. They are pruned at regular intervals to facilitate picking and to stimulate the growth of new shoots. In China and the more backward areas of Japan, tea-gardens are about three to four acres in extent, and the tea is prepared by primitive hand methods. The tea plantations of India, Ceylon, the Dutch East Indies, and other parts of Japan are much larger, varying from 300 to 1000 acres, and up-to-date machinery is used. After the leaves have been gathered they are dried (sometimes in the open-air and sometimes by artificial heat), crushed and rolled, and dried again. At this stage the tea is a dull green colour: for black tea the leaves go through a process of fermentation. Finally, the tea is graded and packed in lead-lined chests for export.

DISTRIBUTION (Fig. 140).—(1) Like rice, tea is essentially a product of the countries of south-east Asia, viz. (*a*) Southern Japan; (*b*) China, particularly the hilly regions of the S.E. between Shanghai and Hong Kong; (*c*) India, especially in the north-east in Assam and the Nilgiri Hills of the south-west; (*d*) Ceylon; (*e*) Java.

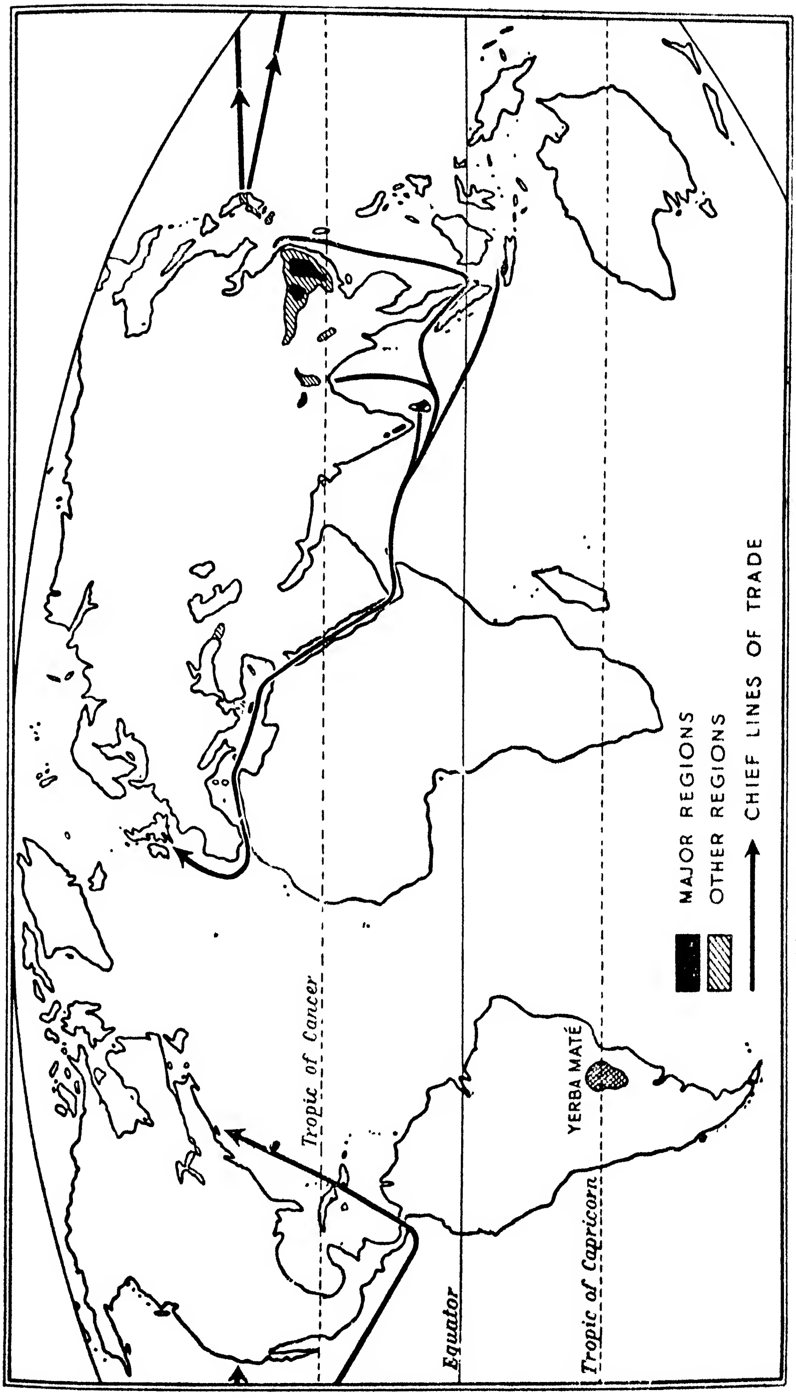


Fig. 140. DISTRIBUTION OF TEA PRODUCTION.

(2) Although there are many other parts of the world with climatic conditions very similar to those of south-east Asia (see page 226), tea cultivation has made very little progress in other continents. Small amounts are produced in (*a*) East Africa (Kenya, Nyassaland, and Natal), (*b*) Fiji, (*c*) Jamaica, (*d*) Transcaucasia.

(3) There have been successful experiments in tea growing in south-eastern Brazil, California, Jamaica, and S. Carolina, but in these areas development has been restricted by the shortage of cheap labour.

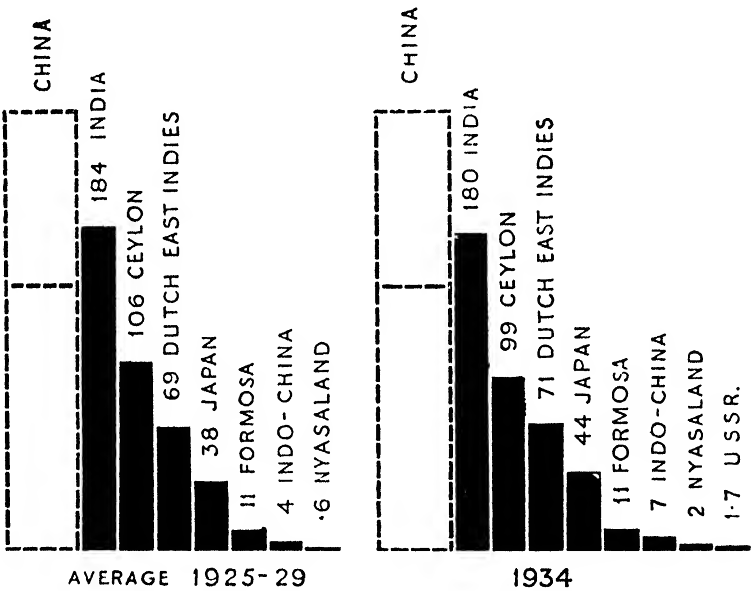


Fig. 141. World Production of Tea in Thousands of Tons. Production figures are not available for China but the estimates range between 300 and 500 thousands per annum.

Trade and Consumption (Fig. 141).—China is the most important producer of tea, and up to 1840 was the only country that exported tea. Tea growing was introduced into India by the British Government, and flourished to such an extent that India is now the leading exporter, and Chinese exports have dropped by 75 per cent. since 1880. Tea cultivation in Ceylon began later than in India, and was introduced when the coffee plantations were destroyed by blight at the end of last century. Ceylon now ranks second

as a tea exporter. The teas of India and Ceylon are exported to Europe and Australia. Japanese teas, however, find their principal market in U.S.A. Tea plantations are very important in western Java, the bulk of the tea being sent to Holland and other European countries. Sumatra, with vast reserves of unused land, has a great future as a tea producer, if the necessary labour can be imported. (Sumatran native labour is less plentiful and less reliable than that of Java.) Tea produced in regions outside Asia is mostly used for home consumption, though Natal has a small export.

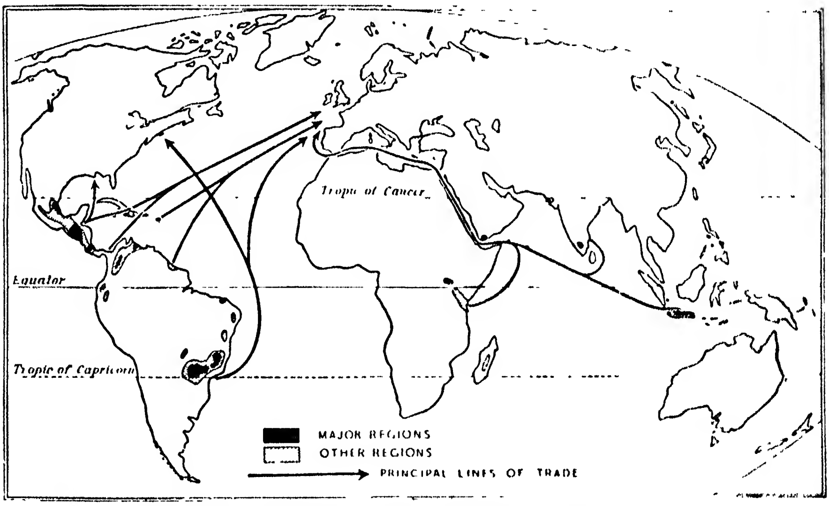


Fig. 142. DISTRIBUTION OF COFFEE PRODUCTION.

Tea is used mainly by the Oriental and English-speaking peoples. The average consumption of tea is:—Australia 11 lb. per head per annum; Great Britain 8 lb.; Canada 4½ lb.; Japan 2 lb.; U.S.A. 1 lb.

In Paraguay and the neighbouring regions of Brazil and Argentina, a special kind of "tea" called Yerba Maté is obtained from a species of holly. Practically the whole of the crop is consumed in S. America.

Coffee

Coffee ranks next to tea in importance as a beverage. It was introduced to Arabia from the province of Kaffa in Abyssinia, and for two centuries Arabia was the main source

of the world supply, but the demand was small. The coffee shrub bears red cherry-like fruits, each of which contains two coffee " berries." They are greyish-green in colour, and are not brown until they have been roasted.

REQUIREMENTS.—

(1) High temperatures of tropical regions.

(2) No frost, which is injurious to the plant.

(3) Heavy rainfall, 75-120 in.

(4) Well drained land.

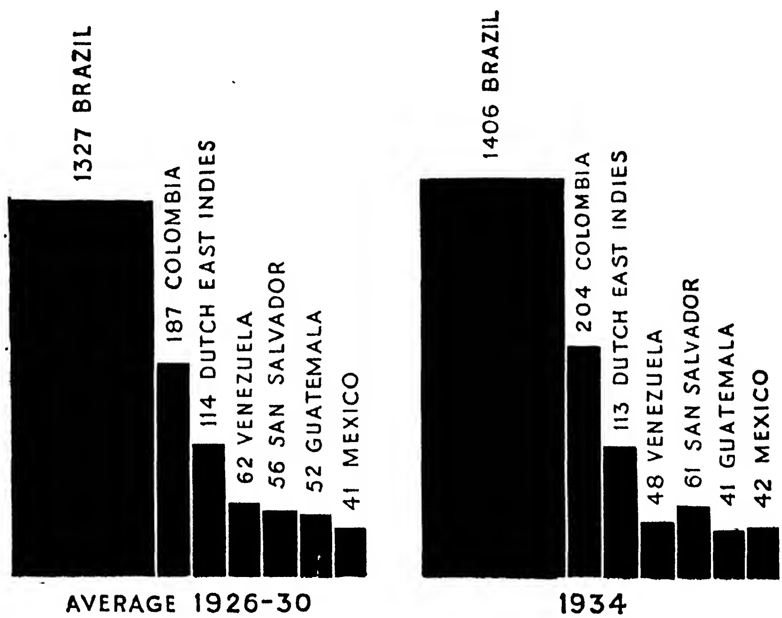


Fig. 143. WORLD PRODUCTION OF COFFEE IN THOUSANDS OF TONS.

(5) Although coffee requires hot conditions it must be sheltered from the direct rays of the sun. Shelter is often provided by planting crops such as Indian corn or bananas between the rows of coffee trees. In Mocha (Arabia) the heat is modified by the prevalence of mists.

It is clear that mountain or plateau slopes on the rainy eastern margins of continents within the tropics will be suitable for coffee growing.

There has been a tremendous increase in the use of coffee during the last fifty years, during which period the main

centres of supply have changed. First, Arabia was the chief producer, then the West Indies, then Java, and finally Brazil, whose production out-distances that of all competitors.

PRODUCING AREAS.—(1) Brazil, on the plateau slopes in the state of San Paulo near Rio de Janeiro. Ten years ago this relatively small area produced 70 per cent., and still produces 60 per cent. of the world's supply, nearly twice as much as the collective supply of all other countries.

(2) The remainder of the coffee crop comes from small and widely-scattered areas, most of which produce a higher grade coffee than that of Brazil, where the methods of preparation for market are not so carefully carried out. Among these districts are:—

(*a*) Central American States and islands, viz. Guatemala, San Salvador, Jamaica, Mexico, Haiti, and Venezuela.

(*b*) East Indies—Java.

(*c*) East Africa—Kenya.

THE PROBLEM OF OVER-PRODUCTION.—Owing to the favourable conditions for coffee growing in Brazil, and the absence of other competitive crops, coffee production has increased so rapidly as to outstrip the expansion of consumption in Europe and America. Since the Brazilian crop is not of the highest quality, the finer grades from other areas are sold first in the world market, and not all the Brazilian crop can be sold, so that a surplus accumulates.

In Brazil the size of the crop varies from year to year. Good weather conditions produce a bumper crop, and normally the year of high production is followed by two or three years of small yield, during which the growers are able to sell at a high price the surplus accumulated during the "high yield" period. High prices encouraged a great extension of coffee planting, principally as a means of investing capital.

Unfortunately, since 1923 there has been a succession of "bumper" crops, and by 1930 large quantities remained unsold. By Government decree a large amount was destroyed, and control was exercised over the area to be planted under coffee each year. Even then the difficulties were not overcome

as a coffee shrub does not commence to bear fruit for about five years. By the coffee restriction schemes planters have been allowed to sell only 40 per cent. of their crop in order to maintain the price level, and in all 35,000,000 bags of coffee (equivalent to 2 years' production) have been destroyed. The present annual crop is about 20,000,000 bags against a demand for 16,000,000 bags annually. What solutions are there to this problem? Many of the coffee planters are experimenting with alternative crops, such as cotton and fruit. Orange cultivation, too, is rapidly developing in the coffee region.

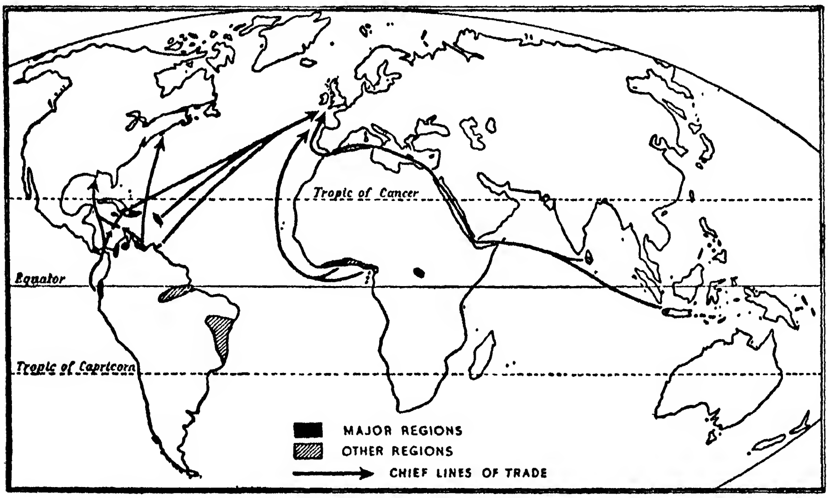


Fig. 144. Distribution of Cocoa Production.

Cocoa

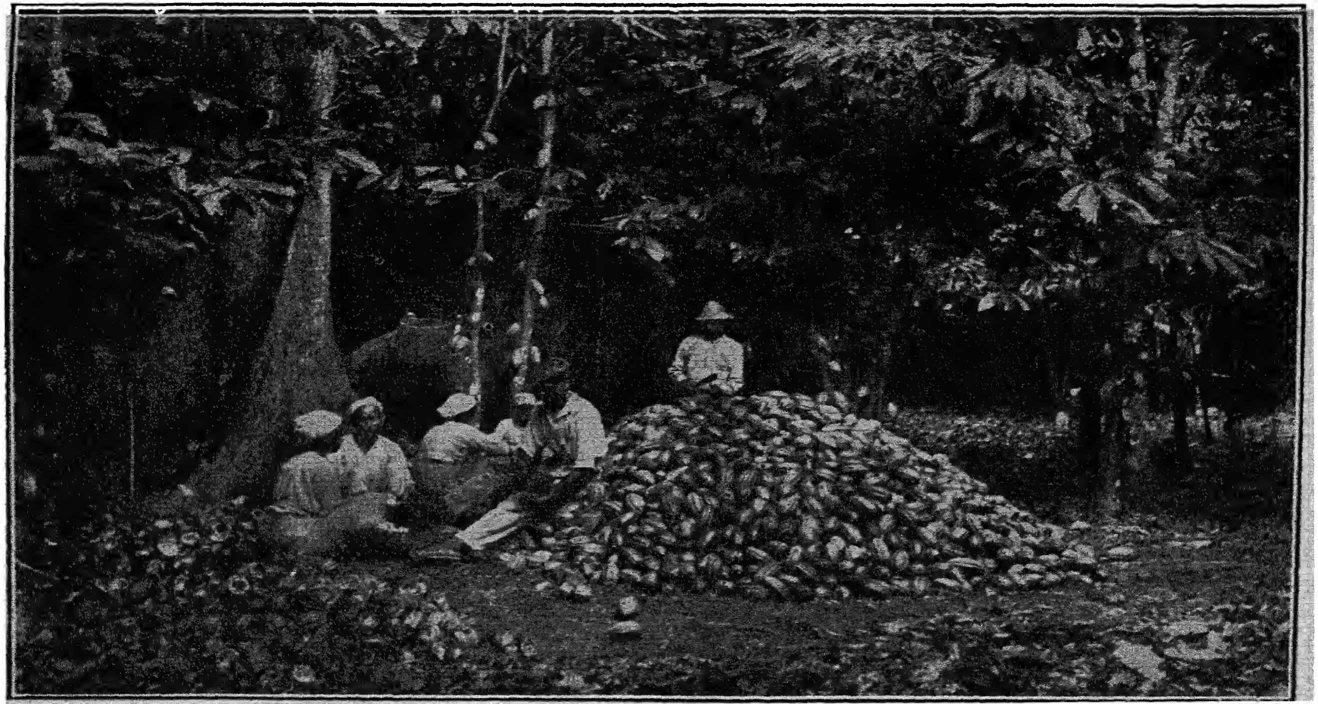
Cocoa is the product of the fruit of the cacao tree. The flowers and fruits of this tree grow directly from the trunks and main branches. The cocoa beans are enclosed in large fruits about 10 in. long. Fifty per cent. of the cocoa bean is a fat known as cocoa butter, which is used in the manufacture of confectionery.

Requirements.—(1) Great heat, *i.e.* an average temperature of about 80° F.

(2) Heavy rainfall—about 80 in.

(3) A deep rich alluvial or volcanic soil.

(4) Shelter from strong winds and the direct rays of the sun.



Cadbury Bros. Ltd.

EXTRACTING COCOA BEANS FROM THE PODS, TRINIDAD.

Labour is cheap and so hand labour can be used. Notice how the cocoa pods grow from the main branches and tree trunks. High winds would cause havoc, hence cocoa must be grown in regions of "calms," or artificial "wind breaks" must be provided.

Because the cocoa tree requires shelter from winds, it grows best in regions of calms such as the equatorial low pressure areas, and on the lee side of mountains. Shelter from the sun is usually provided by planting bananas.

DISTRIBUTION.—(1) *West Africa*, in the Gold Coast, Nigeria, and the islands of Fernando Po, Principe, and St. Thomé.

(2) *America*—Ecuador, Venezuela, Colombia, and in the sheltered valleys of many of the West Indian islands, viz. Trinidad, San Domingo, and Jamaica.

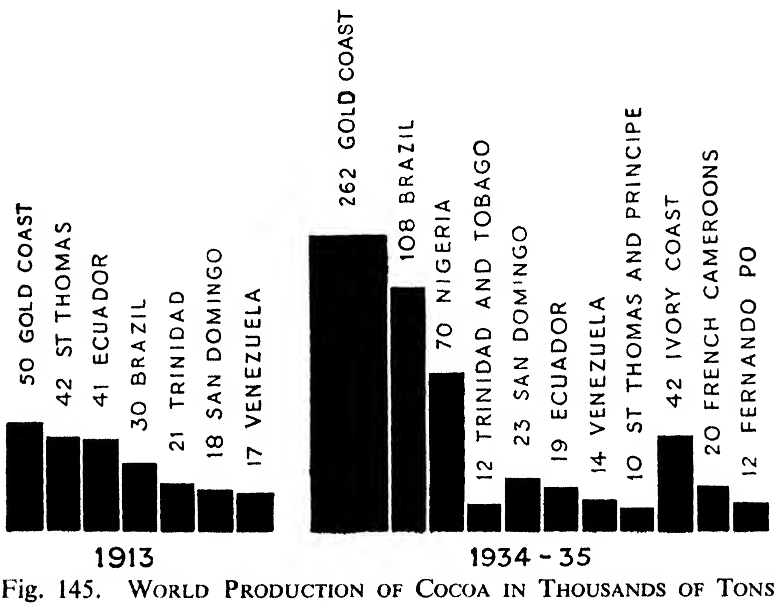


Fig. 145. WORLD PRODUCTION OF COCOA IN THOUSANDS OF TONS.

(3) *Asia*. Cocoa production is as yet not very important in the hot wet lands of Asia, but there are plantations in Ceylon and Java.

CHANGES IN CENTRES OF PRODUCTION.—At the beginning of this century the wet western lowland of Ecuador was the leading producer of cocoa, but the supply was only 19 per cent. of the world output. To-day the Gold Coast is the leading producer, and the West African districts produce over 50 per cent. of the world's cocoa. The bulk of the cocoa used in Britain comes from West Africa. The rise of West Africa as a cocoa producing area was due to:—

(*a*) The greater political stability of the British colonies as compared with the S. American states.

(*b*) The larger supplies of suitable labour.

(*c*) The greater accessibility in the period before the opening of the Panama Canal.

Netherlands Chamber of Commerce

SUGAR-CANE CUTTING : JAVA.

The canes are cut by hand, tied in bundles, and carried, often by a light plantation railway to the crushing mill where the crude sugar is extracted.

(*d*) The encouragement given by British cocoa and chocolate manufacturers.

Sugar-Cane ✓

Sugar is present in many plants and in most fruits, and can be obtained from a variety of plants such as the maple, grape,

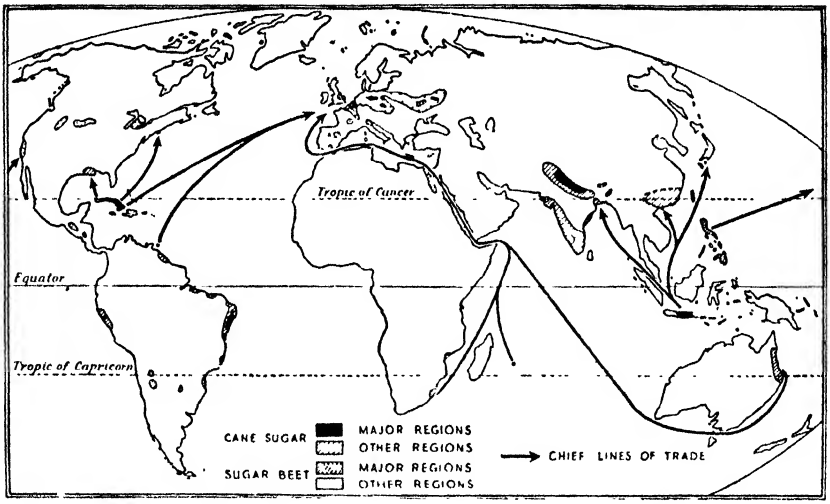


Fig. 146. DISTRIBUTION OF SUGAR PRODUCTION.

date, maize, etc. But the bulk of the world's sugar is obtained from either the sugar-cane or the sugar-beet. As the former is a product of the hot zones of the world, and the latter grows in the cool temperate zone, sugar is an example of a product in which there is competition between regions vastly different in development. This has led to a number of difficult problems.

REQUIREMENTS.—Sugar-cane requires:—

(*a*) Abundant heat with an average temperature of about 80° F.

(*b*) An abundant rainfall.

(*c*) A rich, deep soil. Where soil has been exhausted heavy manuring is essential.

(*d*) A lowland area.

These conditions are very similar to those for rice cultivation. In fact, good sugar-cane land is often good rice land, and vice versa.

Sugar-cane does not require the same amount of careful cultivation as sugar-beet, but the bulkiness of the cane makes transport a serious problem, especially in view of the damp and often muddy nature of the ground in which it grows. Sugar-cane is usually grown on estates of several thousand

acres which have their own railway tracks and refineries, and are often not far from the sea.

DISTRIBUTION.—Since sugar-cane is a product of damp tropical lowlands, its cultivation, except in India and China, is mostly associated with islands and coastal plains (see Fig. 146). The most important sugar-cane producing islands are Cuba, Java, Hawaii, Porto Rico, the Philippines, Mauritius, and Jamaica. In India and China sugar is cultivated on the wetter lowland areas; in Brazil on the hot, wet east coast plains, in the hinterlands of such towns as Pernambuco and Bahia; in the United States in the Mississippi delta; in the coastal lowlands of Natal; and on the hot, wet east coast plains of Queensland. In the last few years the output of cane-sugar in Queensland is steadily increasing, mainly as a result of the policy of Imperial Preference which allows colonial sugar to be imported into this country on lower tariffs than the sugar from countries outside the Empire. The Australian sugar is cultivated by white settlers, in spite of the great heat and humidity of the climate.

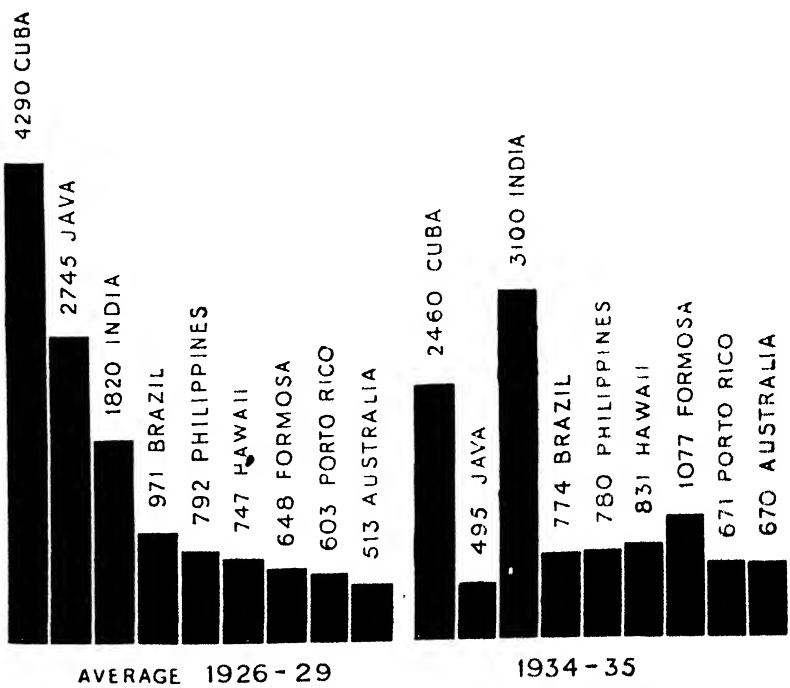


Fig. 147. WORLD PRODUCTION OF CANE SUGAR IN THOUSANDS OF TONS.

SUGAR TRADE.—(1) Java sugar is largely exported to the countries of south-eastern Asia, which in spite of their large home supplies are not self-supporting.

(2) The cane-sugar of Australia, Natal, and the British West Indies is exported to the British Isles.

(3) The sugar of the Philippines, Hawaii, and Cuba finds its chief market in the United States, because of the "preference" given by that country to these islands.

Sugar-Beet

During the Napoleonic wars France was unable to obtain supplies of sugar from her colonies, and it was then that sugar was first obtained from the sugar-beet. From that time onwards types of sugar-beet, giving a larger yield of sugar, have been developed. In contrast to sugar-cane the sugar-beet grows in the cool temperate zone as a crop of the normal four years' rotation. It requires (*a*) a good deep stoneless soil; (*b*) rain from June to August; (*c*) a dry period in the autumn when the roots are lifted; (*d*) careful cultivation, especially weeding and thinning, so that much cheap labour is required. The extraction of sugar from the sugar-beet is a seasonal industry. From October to January the factories are working at great pressure. During the remainder of the year a few men only are employed, who thoroughly overhaul the machinery in preparation for the next season.

DISTRIBUTION.—(1) The most important region for sugar-beet cultivation is the central plain of Europe extending from Ireland through East Anglia, N. France, Holland, and Belgium, Germany, Czecho-Slovakia, and Poland to Central Russia. Four regions are pre-eminent: (*a*) N. France and Belgium; (*b*) Germany, around Magdeburg; (*c*) Czecho-Slovakia; (*d*) Russia, around Kiev and Kursk.

(2) Sugar-beet is grown to a less extent in North-Central U.S.A. and South-Central Canada (Fig. 148). Slightly under 50 per cent. of the world's sugar supply is derived from sugar-beet.

The beet-producing countries (except Britain) are self-supporting and have a surplus for export. Thus beet-sugar and cane-sugar compete in the world markets.

THE PROBLEMS OF BEET-SUGAR AND CANE-SUGAR.—Competition between the growers of sugar-cane and sugar-beet first became acute in 1902. The West Indian industry suffered greatly, and the growers were faced with possible disaster which was only averted by political action when European subsidies and tariffs were removed to secure freedom of trading facilities. The most acute sugar problems of the present day are traceable to the War (1914-18). The European sugar supplies then ceased to be available and there was a world shortage of sugar. Under this stimulus there was a great increase in the planting of sugar-cane, especially in

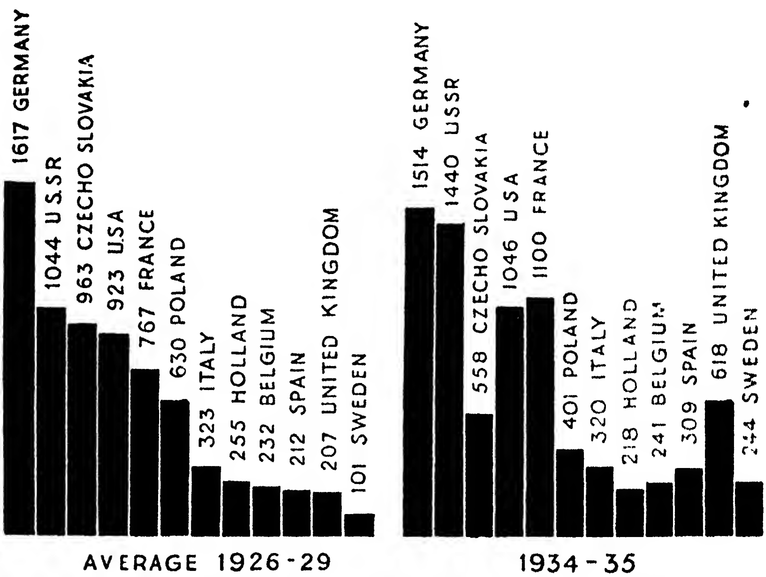


Fig. 148. WORLD PRODUCTION OF BEET-SUGAR IN THOUSANDS OF TONS.

Cuba. Prices rose so high that this period was known as the " Dance of the Millions " in Cuba.

After the War the European sugar-beet industry expanded again (protected by tariffs), and by 1920 had recovered more than its former importance. This great increase in world supplies caused prices to fall at an amazing rate, and few countries could find markets for the whole of their crops. In 1931 the Chadbourne Scheme was drawn up, by which producers agreed to restrict their output. By this restriction the Cuban industry suffered heavily. It caused unemployment,

lower wages, and depressed standards of living, unemployment in transport and shipping services, and grave riots and political difficulties in Cuba. The decrease in production in both Cuba and Java is traceable to the 1931 restrictions.

Mutton

The distribution of sheep is discussed on page 303. Sheep reared for mutton thrive best on good pasture land, though not as rich as that required for cattle-rearing. The chief wool-producing countries are also the chief mutton-producing countries, but, whereas Australia leads as a wool exporter,

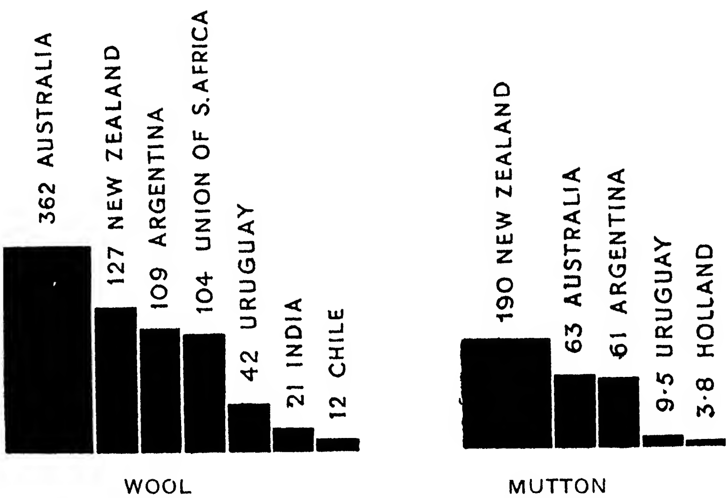


Fig. 149. Chief Exporters of Wool (1933) and Mutton (1934) in Thousands of Tons.

New Zealand exports more mutton, Australia taking second place, as is clearly seen in Fig. 149. In New Zealand the sheep lands are the Canterbury Plains on the eastern side of South Island. In Australia, the Murray-Darling basin is the principal sheep-rearing area, but this region is more liable to drought than the New Zealand plains. The Plate lowlands and Uruguay are the chief South American centres, but there is another region of importance in the extreme south of Argentina, and Chile extending into Tierra del Fuego. Britain produces a large amount of mutton, but in spite of this she is the leading importer. In North America, sheep-rearing is important in Ohio and on the western plateaux, but most of the mutton

and wool are used in the home markets. In South Africa, sheep-rearing is concentrated in the uplands of the east of Cape Colony, and some wool is exported.

Beef and Dairy Produce

Cattle are reared for beef, milk, hides, and as beasts of burden. Cattle need richer pastures than sheep, and where they are reared primarily for dairying the ideal climate is one of cool, damp summers and warm, damp winters, such as is experienced in Ireland or Cornwall. Under such conditions grass will grow throughout the year, and there is little

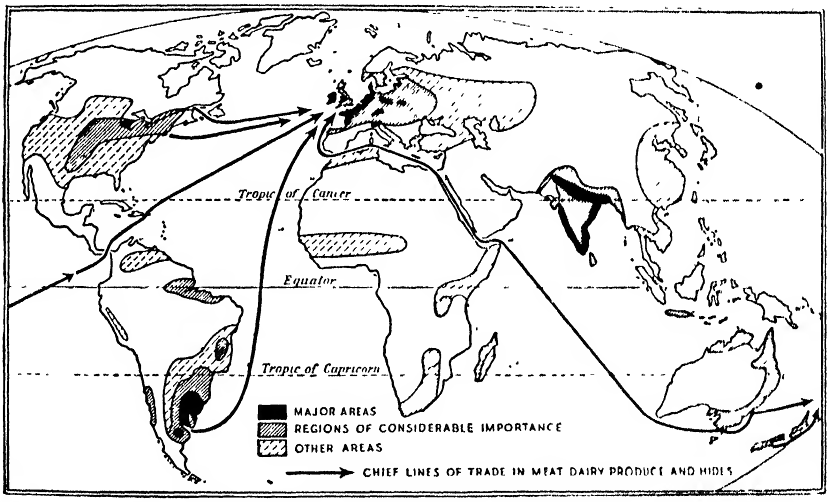


Fig. 150. DISTRIBUTION OF CATTLE.

necessity to resort to indoor feeding, such as is practised in the lands of more extreme climate, such as Germany, Poland, etc.

Cattle will thrive in temperate and tropical lands. India has far greater numbers of cattle than any other country, but there they are used as " work " animals. The Hindus do not eat beef, and the Moslems eat very little. The Indian cattle yield little milk. Therefore India is important for neither beef nor dairy produce. Apart from India there are *three outstanding* regions for cattle production (Fig. 150):—

(1) The plains of Western Europe, including Ireland, England, N. France, Belgium, Holland, Denmark, Germany, Switzerland, and Northern Italy.

(2) The north-central plains of U.S.A. (*i.e.* the maize belt), but vast numbers of cattle are also reared in the high western plains.

(3) The temperate lowlands of South America, including the Pampas lands, the Parana lowlands, Uruguay, and the extreme south-east of Brazil.

In the early days of cattle-rearing, meat, which would not keep, could not be exported, and the chief exports were hides, fat, and bones. Hides and bones are still exported, the latter in large quantities to North Staffordshire for use in the manufacture of "bone china." At a later stage meat extracts were made and exported, but it was not until the processes of canning and refrigeration were perfected about 1870, means of transport improved, and carriage costs reduced that meat could be exported in large quantities to Europe. At first the meat was frozen, but later it was "chilled," for it was discovered that meat could be preserved at temperatures slightly above freezing point, and that the fibres of the meat are not torn by "chilling" as they are by freezing. From 1870 onwards the export of meat increased rapidly. To-day Argentina exports about 60 per cent. of the world's beef exports, the remainder coming principally from south-east Brazil, Australia, and New Zealand. Argentina and Brazil lead in the export of hides. The beef produced in the European zone is used for home consumption, and the American supplies, though very large, are also used in America, leaving only a small percentage for export to Europe.

DAIRY PRODUCE.—Cattle-rearing regions near to large centres of population usually have a highly-developed dairying industry to supply milk, butter, and cheese.

The greatest dairying regions are:—

(1) The cool, damp areas of North-West Europe, viz. in Denmark, Holland, and the British Isles and north-west France.

(2) Switzerland, where the Alpine pastures are the basis of important dairying activities.

(3) America, in the region south of the Great Lakes extending eastwards to New York and including the St. Lawrence lowlands of Canada.

During the post-war years there has been a great increase in dairying in the temperate lands of the southern hemisphere, especially in the North Island of New Zealand, the east coast plain of Australia, and the eastern pampas of Argentina. The butter and cheese of these countries find a ready market in Europe, and, in spite of long distance transport, often sell at a lower retail price than butter and cheese made in Europe.

CHAPTER XX

THE MAJOR RAW MATERIALS

Rubber

Rubber is the coagulated juice or latex of various tropical plants and trees, the chief of which is the Hevea, a native of the Amazon forest. The Hevea tree yields a high quality rubber known as Para rubber, Para being the port at the mouth of the Amazon from which most of such rubber used to be exported. Rubber was introduced into Europe early in the eighteenth century, and for nearly a hundred years

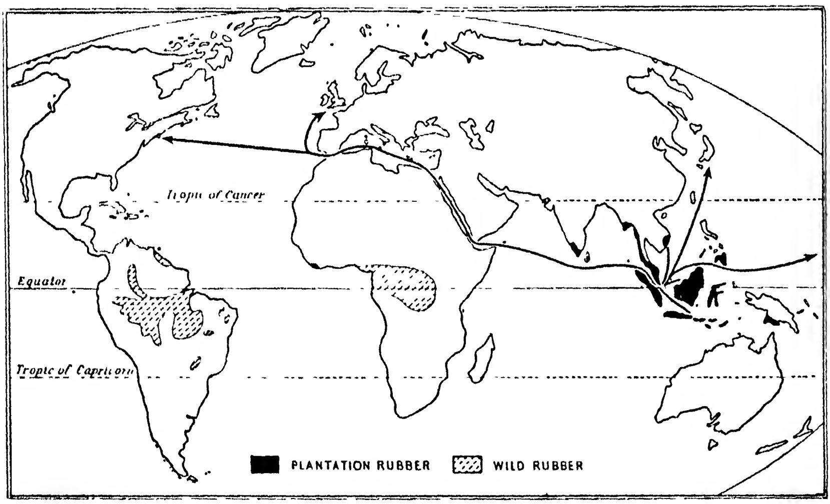
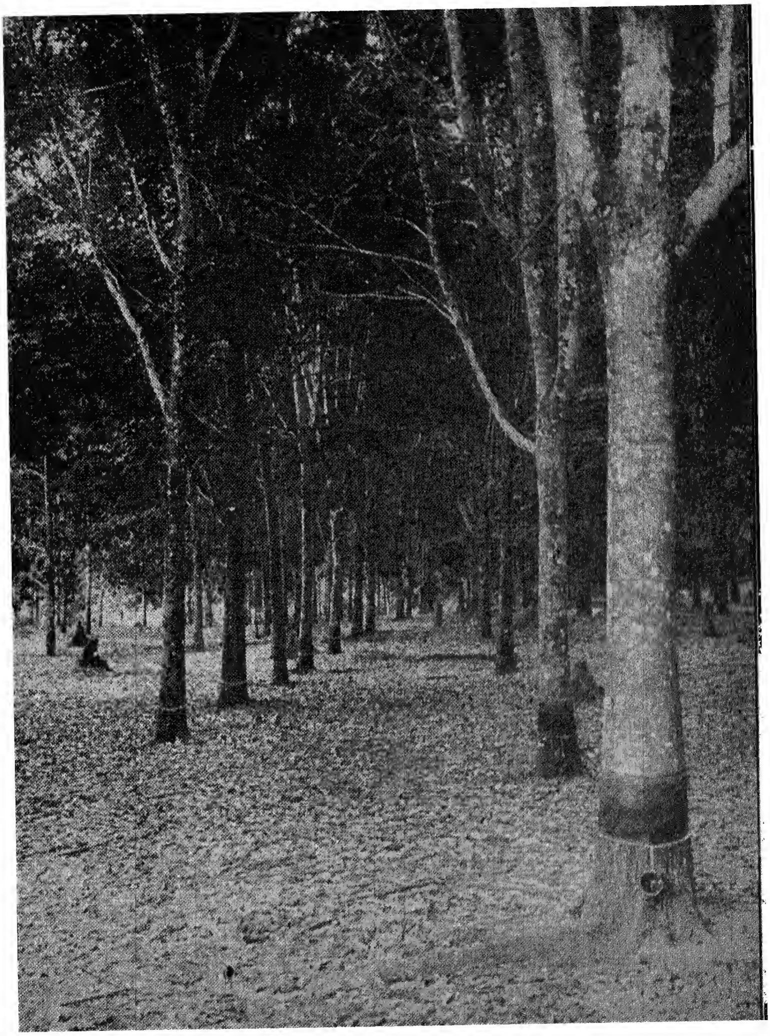


Fig. 151. DISTRIBUTION OF RUBBER.

was only used for erasing pencil marks. In the early nineteenth century Mackintosh discovered that rubber could be used for making cloth waterproof, and in 1839 a further impetus was given to the use of rubber by the discovery of the vulcanising process, *i.e.* the addition of sulphur which makes rubber hard. It was not, however, until the end of the nineteenth and the beginning of the present century that the demand for rubber really attained great proportions.

The rise of the bicycle, motor, and electrical industries have resulted in a stupendous growth in rubber production. The old uneconomical method of tapping the irregularly-distributed wild rubber trees in the equatorial forest has



Malayan Information Agency

RUBBER PLANTATION, MALAYA.

The rubber trees are planted at regular intervals and the ground is kept free from weeds. The bark of each tree is cut, and small cups are placed in such a manner as to catch the latex which issues from the cuts. Rubber is prepared from the latex.

given place to the organisation of compact plantations. The advantages of the plantation system are:—

(*a*) That better quality rubber is obtained.

(*b*) There is a higher yield from each tree, and the collection is controlled.

(*c*) The collection of the rubber is much easier.

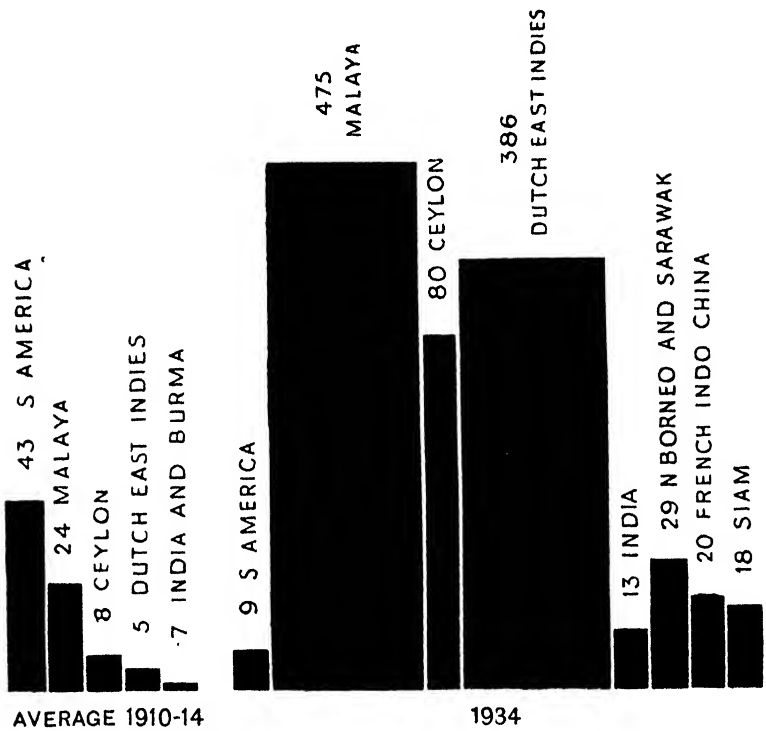


Fig. 152. World Production of Rubber in Thousands of Tons.

Requirements.—The rubber trees require:—

(*a*) Great heat, a mean temperature of 80° F., never falling below 70° F.

(*b*) Heavy rainfall, 80 in. and upwards with no periods of drought.

(*c*) A lowland situation, but with good drainage and deep rich soil.

From the foregoing conditions it is clear that rubber trees will grow best in the equatorial lowland areas. An adequate

supply of labour is a vital factor in the collection and preparation of rubber for market. The Amazon basin is scantily peopled, and the natives do not easily adapt themselves to routine work. When the world demand for rubber increased, experiments were made to establish plantations elsewhere. In 1876 seeds from Brazil were germinated at Kew, and the young trees were dispatched to India and Ceylon, and thence to the Malay States and the Dutch East Indies. The remarkable increase in the world output of rubber and the change from S. America to Asia as the main source of supply is shown in Fig. 152.

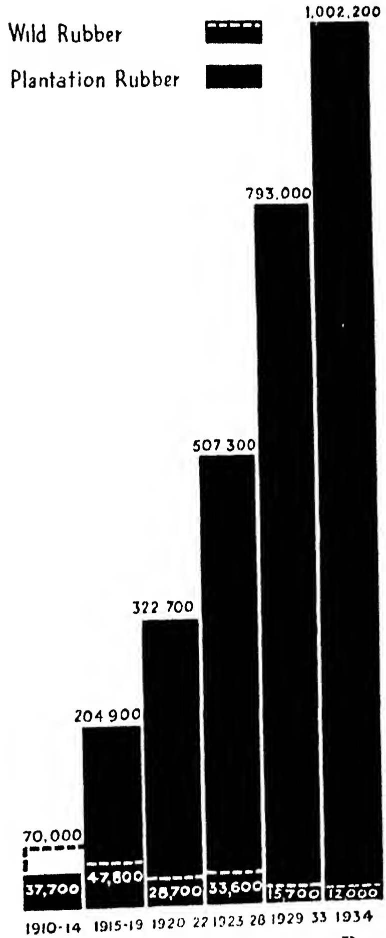


Fig. 152 (*a*). To Show the Relation Between the Production of Wild and Plantation Rubber from 1910 to 1934 (in Tons).

The Problems of Over-production.—Before 1914 supplies of rubber could not meet the ever-increasing demand, and prices rose to 14s. per lb. The stimulus of high prices caused a great extension of rubber planting. By the post war period the rubber output was so large that in spite of increased demands, prices fell to less than 1s. per lb., and many planters were faced with bankruptcy. In 1922 the Stevenson scheme of restrictions was inaugurated, and prices rose once more. But unfortunately the planters of the Dutch East Indies were not restricted in their output, and the increasing quantities of Dutch rubber entering the world market caused prices again to fall. The Stevenson scheme was abandoned in 1928.

In Sumatra an interesting extension of the rubber forest is taking place. Native farmers cultivate a plot of ground for two or three years and then, its fertility being spent, abandon it for a new plot. During the planting of the last crop of rice on a plot of ground, natives set rubber seeds, so that the abandoned plot, in time, becomes a rubber forest, from which rubber can be collected when prices are high. Thus the Sumatran rubber output is steadily increasing.

Cotton

Cotton is the most important of all fibres used in the manufacture of textiles. Before 1800 it was one of the most expensive fibres because of the cost and difficulty of its preparation for the market. The cotton seeds had to be removed from the fibres by hand. In 1793 the cotton gin, a machine which separated the seeds from the fibre, was invented. This labour-saving machine cheapened the production of cotton, and its cultivation extended rapidly, particularly in the southern United States. There are many varieties of cotton, and the value of each type depends largely upon the length of the fibre or "staple."

Sea Island cotton, grown on the coastal lands of Georgia and in the West Indies, has fibres over two inches long, and surpasses all other varieties. Meade cotton is a close rival of Sea Island cotton, and is tending to replace it in U.S.A., because of the susceptibility of the latter to attack by the boll weevil, an insect which causes the cotton bolls to shrivel up. Egyptian cotton is also of excellent quality, and is grown by irrigation in a very dry and hot climate. Attempts to grow Egyptian cotton elsewhere have not been successful (except in hot desert and semi-desert regions) by irrigation as in the lower Colorado valley, and the coastal desert of Peru.

The bulk of the world's cotton crop is known as American Upland with fibres less than 1 inch long. In many cotton-producing countries cotton is short-stapled and only suitable for the spinning of coarse threads and the weaving of coarse materials.

Conditions for Growth.—Cotton requires:—

(*a*) Ample rain in the early growing season.

(*b*) A dry picking season in the autumn.

Mondiale

COTTON PICKING, NORTH CAROLINA.

For the picking of cotton, hand labour is necessary, no satisfactory machine having yet been invented.

(*c*) At least seven months without frost.

(*d*) A summer temperature of 75° F.

(*e*) Abundant labour in the picking season.

Cotton grows between 40° N. and 30° S., its most northerly extension being in the southern Ukraine (Fig. 153). Although the cotton plant needs heat and moisture, it does not yield well in regions of constant heat, but will flourish best near to the cooler and drier margins of the cotton-growing regions. The approach of winter cold or of drought stimulates the plants to higher yields. Cotton is grown on small

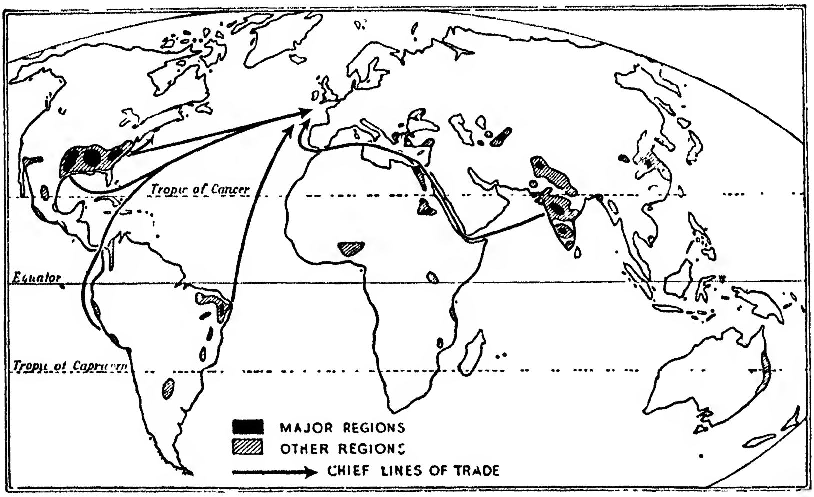


Fig. 153. WORLD DISTRIBUTION OF COTTON.

farms by poor peasant farmers, and not on extensive plantations. This is partly due to the social and agricultural background of the cotton-growing countries, China, India, Egypt, etc., and largely to the vast amount of labour required for picking. No machine has yet been invented which will pick the cotton bolls successfully, for the bolls do not all ripen at the same time.

CHANGES IN COTTON PRODUCTION.—(1) A study of Fig. 154 will clearly show that the American output of cotton is at present decreasing. This is largely the result of agricultural depression in U.S.A. (cf. maize), and conditions and output may improve. The American cotton region is the most

important in the world. Cotton is cultivated in some eighteen states of the S.E. of the United States, being limited on the west by aridity and on the north by frost. The Gulf Coast Plains and Florida are too wet for cotton growing. There are three American areas of outstanding importance:—

(*a*) The Black Prairie of Texas.

(*b*) The Mississippi bottoms, viz. the flood plain of alluvial soil between Memphis and Vicksburg.

(*c*) The Rich clay belts of Georgia and S. Carolina.

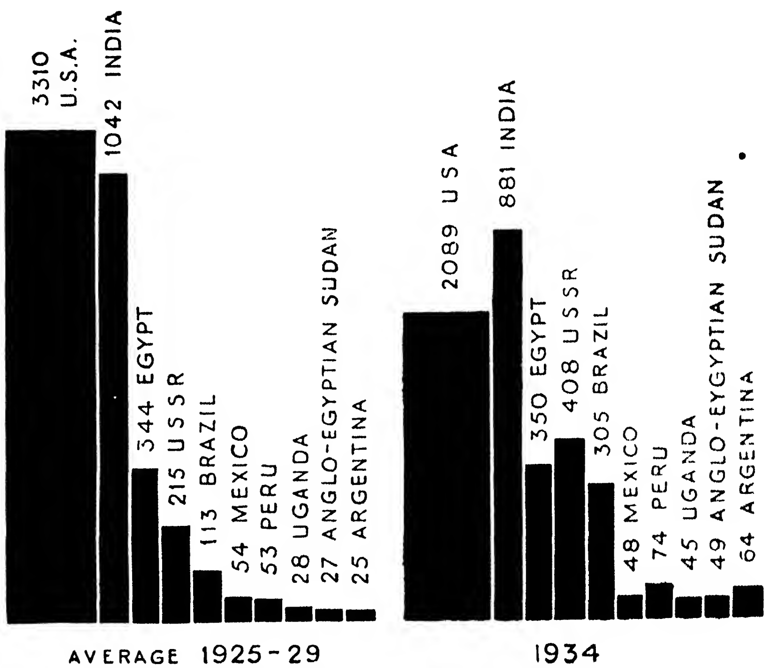


Fig. 154. World Production of Cotton in Thousands of Tons.

Under normal conditions the United States supply nearly 60 per cent. of the world's cotton crop, and the manufacturing regions of other countries largely depend on the American surplus for their raw material.

(2) Russia is producing far more cotton than formerly, as a result of the development of Russian Turkestan under the Five Year Plans, the opening up of new cotton lands in the southern Ukraine, and Russia's determination to supply her own raw material.

(3) In Japan, cotton cultivation has virtually disappeared, the land being used for rice growing. Japan needs cotton for her textile manufactures, and so Korean supplies are increasing to meet this demand.

(4) The cotton mills of Lancashire were badly affected by the cotton shortage resultant on the American Civil War. The British Cotton Growers' Association was formed to encourage cotton production in suitable areas within the Empire in order that Lancashire should escape from its dependence on the United States. This accounts for the general

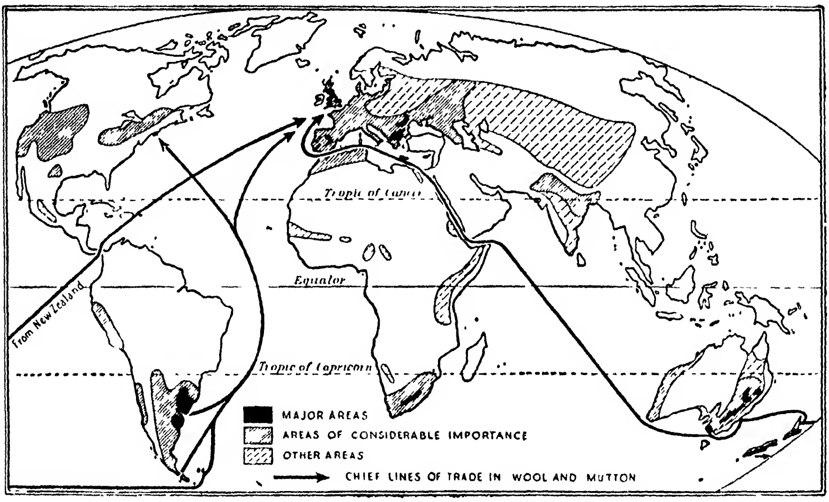


Fig. 155. DISTRIBUTION OF SHEEP.

increase in the African crops, particularly in the Anglo-Egyptian Sudan, where millions of pounds have been spent on irrigation works (*e.g.* Sennar Dam on the Blue Nile). At some time in the future a dam may be constructed across the outlet of Lake Tsana (Abyssinia) to conserve the waters during the wet season, and so permit a further extension of irrigation in the Sudan.

(5) Other cotton producing areas are Uganda, northern Nigeria, Nyasaland, and Rhodesia in Africa; southern Turkey and Syria and Iraq in south-western Asia; Mexico, the West Indies, Venezuela, eastern Brazil, northern Argentina, and western Peru in South America; and eastern Queensland in Australia.

Although the cotton crop is distributed throughout so many countries, a shortage due to a bad season in one region cannot necessarily be balanced by a bumper crop in another, for the machinery used for spinning and weaving long-stapled varieties is not the same as that used for short-stapled varieties. Hence a particular manufacturing area may be badly affected by the failure of the crop in a single area of production.

COTTON MANUFACTURING.—The principal cotton manufacturing regions of the world are S.E. Lancashire, the New England States, N. and S. Carolina, India (Bombay), China (Shanghai), Japan (Osaka), northern Italy, Switzerland, N.E. France, Belgium, and Westphalia.

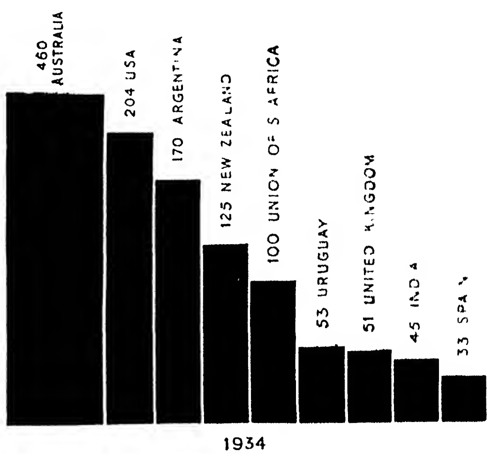


Fig. 156. LEADING PRODUCERS OF WOOL IN THOUSANDS OF TONS.

Wool

Sheep-rearing areas can be divided into two main groups:—

(1) The unproductive lands of the "old" countries of the northern hemisphere, viz. central Spain, the highlands of the British Isles, and the highlands of S.E. Europe.

(2) Those "new" countries of the southern hemisphere, where land is plentiful and cheap, and the population density is relatively low, viz. Australia, S. Africa, Argentina, New Zealand, and Uruguay.

The sheep-rearing areas of the mountain zones of U.S.A. fall into the second category. American wool is used for American woollen mills, and there is no surplus for export. The countries of the southern hemisphere are the leading producers and exporters. Australia produces about 25 per cent. of the world's supply, so that no country dominates the wool trade (cf. Brazilian coffee, American cotton, Asiatic

rubber). Sheep are reared both for wool and meat, but sheep which yield excellent wool usually provide poor meat, and vice versa. There are two main classes of wool, Merino wool, of a fine silky texture, and cross-bred wool, of less fine quality.

But the rearing of cross-bred sheep is of great advantage to the sheep farmer, for if wool prices fall he can increase his income by the sale of mutton. It is because sheep farmers can increase their supply of wool relative to mutton, and vice versa, that the wool markets of the world have not been subjected to the restrictions applied to other commodities

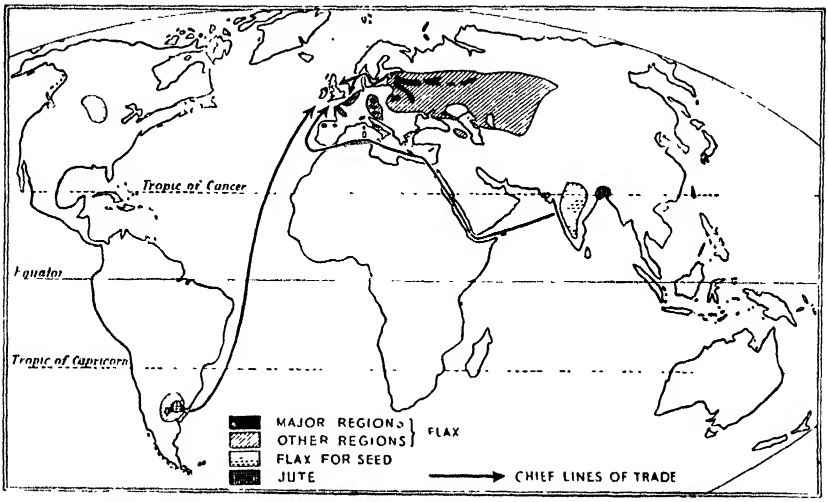


Fig. 157. DISTRIBUTION OF FLAX, LINSEED AND JUTE.

such as rubber, sugar, etc., and that financial crises have not developed to the same extent in the wool trade.

Other types of wool, or animal fibres, are used in the textile industries. The most important are:—

(1) The wool of the alpaca and vicuna, animals which live in the Andean regions of South America.

(2) Camel's hair.

(3) The wool of the Cashmere goat.

(4) Mohair, the wool of the Angora goat, a native of Asiatic Turkey. The chief centre of production is S. Africa.

Flax

Flax is a fibre obtained from the stems of the flax plant. After the plant has been pulled it is "retted," *i.e.* soaked in water to produce partial decay which facilitates the removal of the fibre. The flax plant yields seed (linseed) as well as fibre. If the plant is being grown for fibre it requires cool damp conditions of the cool temperate zone (*i.e.* 48° N. to 55° N.). A hot dry summer results in coarse fibre. The seeds are set very closely, so that the plant will grow as tall

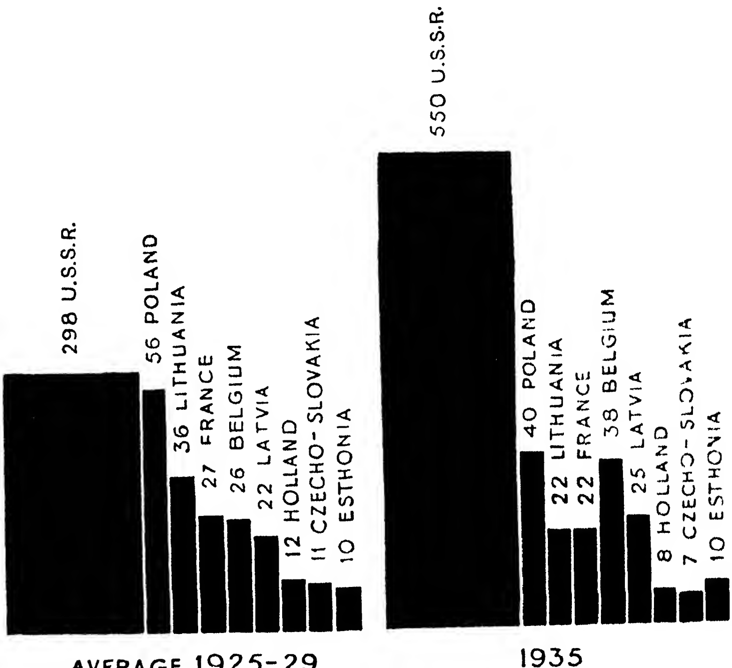


Fig. 158. World Production of Flax in Thousands of Tons.

as possible and so increase the fibre yield. Flax exhausts the soil, so that it is rarely grown on the same piece of ground more than once in 8 years.

For linseed, flax is grown in warmer latitudes (see "Oil Seeds").

Distribution of Flax-Growing.—The distribution of flax is in many ways similar to that of sugar-beet, for the outstanding regions are in the Central Plain of Europe extending

from Ireland to Russia. The latter country is the leading producer. The post-war political chaos in Russia caused a great decrease in flax export, but Russia is once more the leading producer, followed by Poland. The new Baltic States, Estonia, Latvia, and Lithuania, export considerable quantities. Belgian flax is of very high quality, and although there are important linen manufactures in Belgium, much of the flax is sent to Northern Ireland, where the local flax crops are insufficient.

Linen Manufacture. — The manufacture of linen is especially important in Great Britain, *i.e.* in Northern Ireland and Eastern Scotland. Irish linen is exported to all parts of the world. Other manufacturing centres are Northern France, Belgium, the Ruhr valley, and Northern Italy. Japan has greatly increased her linen manufactures in recent years, and grows more flax than Northern Ireland.

Hemp

True hemp is, like flax, a fibre obtained from the stem of a plant. Its preparation resembles that of flax, and its geographical distribution is very similar, for the largest supplies of European hemp come from the flax regions of Russia. Hemp is used for the manufacture of ropes, string, the backing of carpets and linoleum, canvas, etc. Italy is the second largest European producer, and Italian hemp from the district around Bologna is of excellent quality.

There are many other fibres to which the name " hemp " is applied.

(1) Manilla Hemp.—This is cultivated only in the Philippines. Attempts to introduce it into other countries have failed. It is the fibre of the stalk of a plant allied to the banana plant, and in fact, is so similar to the banana, that only experts can detect the difference. It makes very strong rope, especially for ships' rigging, and is used in the manufacture of strong paper, and to make the binding cord used in harvesting machines.

(2) Sisal Hemp.—This is the fibre of the stiff sword-like leaves of the henequen plant. Practically the whole of the world's supply comes from the lowland peninsula of Yucatan

in Mexico. It has been introduced with some success to some of the West Indian islands and to Kenya and Tanganyika Territory. It is not as strong as Manilla hemp, but is cheaper.

(3) PHORMIUM.—Phormium, or New Zealand flax, is a kind of hemp grown throughout New Zealand.

Jute

Jute is the cheapest of all fibres. It cannot be bleached, and is used for the manufacture of cords and sacking. It has been called "the brown paper of wholesale trade," for it is used for packing many commodities of world trade, viz. for wrapping bales of cotton and wool; as sacks for coffee, wheat, etc.

About 99 per cent. of the world's jute is produced in the lower Ganges valley, and the greatest number of jute mills are in the neighbourhood of Calcutta. It is manufactured in Dundee and in Philadelphia (for carpet backing). Some small quantities are cultivated in Formosa and Malay, and because of the decreasing exports from India, attempts are being made to extend its cultivation.

Silk

Silk is obtained from the cocoons of the silkworm. As the chief food of the silkworm is the leaves of the white mulberry, the distribution of the silkworm corresponds closely to the distribution of the mulberry tree. As a second crop of leaves is required for feeding, the temperature must be at least 55° F. for three months, but the silkworm cannot stand temperatures less than 60° F., so in many of the cooler areas they are kept in slightly warmed rooms. The unwinding of the silk fibres from the cocoon demands an abundant supply of highly-skilled cheap labour, and this, even more than climatic conditions, limits silk production.

The silk production of the world is centred in two large areas:—

(1) The south-east of Asia, supplying about 80 per cent. of the world output.

(2) The Mediterranean countries of Europe, which supply nearly all the remainder.

In China, silk production is chiefly centred in the Yang-tse-Kiang and Si-Kiang valleys. It is possible that China is still the greatest producer, but so much is used in the country itself that exact amounts cannot be estimated.

Japan's output has increased enormously in recent years, and she is the leading exporter, sending very great quantities to the United States. Silk culture is to Japan what sheep-rearing is to England, for the mulberry can be grown on mountain slopes too steep for any other type of cultivation, and so it is a

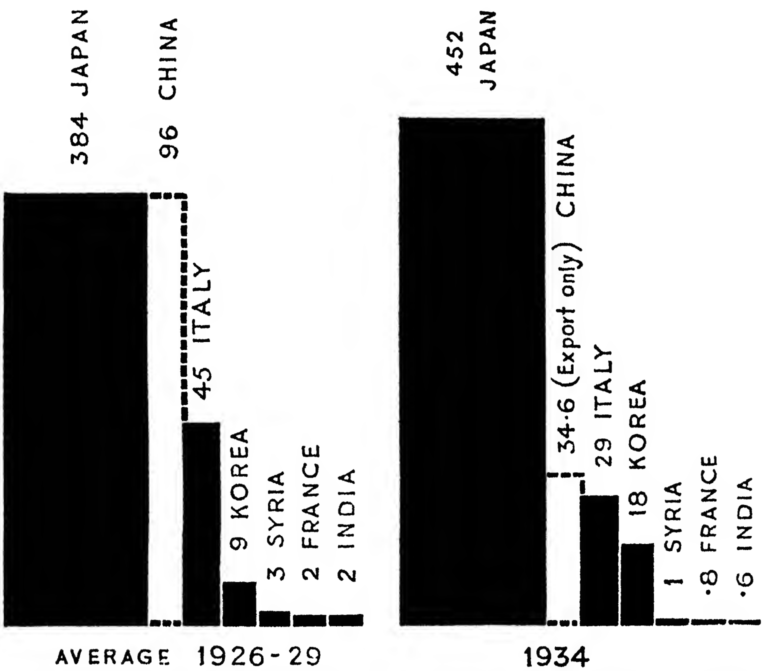


Fig. 159. World Production of Silk in Hundreds of Tons.

valuable means of using land that would otherwise be unproductive. In India, silk culture is practised in scattered areas extending from Mysore to Kashmir.

Silk culture began in the Mediterranean lands as far back as 600 A.D. To-day the fertile plains of the Po valley yield about 90 per cent. of the European supply. The trees are used as supports for grape vines, and crops of wheat are harvested on the intervening land, an example of intensive agriculture in a land of dense population. The silk is woven in the factories of Milan.

Silk is also produced in the Rhone valley south of Lyons; in Eastern Spain; and in the western plains of Asiatic Turkey.

Artificial Silk or Rayon

Artificial silk is made by the treatment of wood pulp, cotton, and other vegetable materials with various chemicals to form cellulose. This is forced through minute holes in glass to make silk threads. The first artificial silk was made as far back as 1884, but its actual production on a commercial

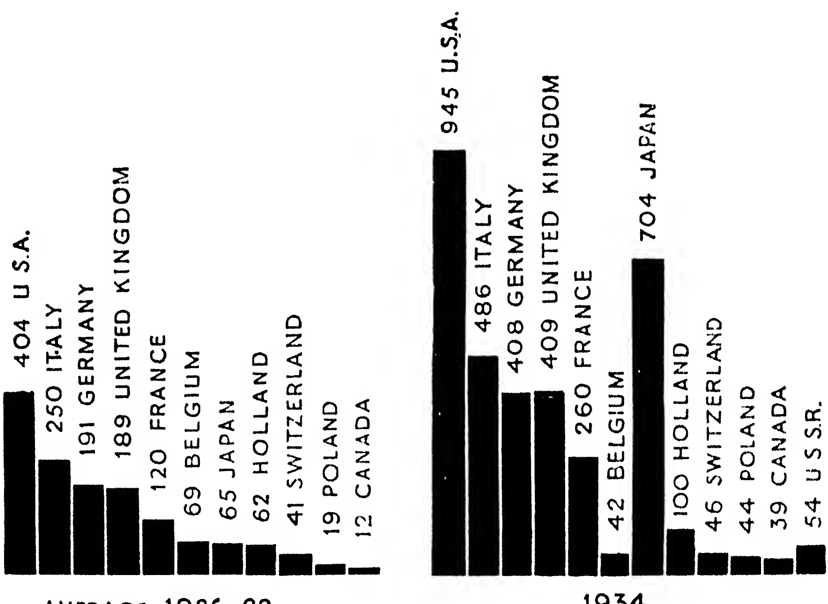


FIG. 160. WORLD PRODUCTION OF RAYON IN HUNDREDS OF TONS.

scale is much more recent. It has not replaced real silk, for apart from its appearance, artificial silk has few of the qualities of pure silk. However, owing to the abundance and cheapness of the necessary raw materials, its output is now greater than that of real silk. Its tendency is to replace fabrics made of cotton, wool, etc., but it is also extensively used for mixing with the other textile fibres. The United States and Japan are the greatest producers (see Fig. 160). Owing to the continued depression in the cotton industry in Lancashire, many of the mills have been converted for the production of artificial silk.

Oil Seeds

Most of the vegetable oils are obtained from the seeds or fruits of plants. These plants are of infinite variety, and grow in almost every type of climate. Each vegetable oil has its special uses, but in general these oils are used in the manufacture of margarine, soap, candles, toilet requisites, varnishes, paints, etc. After the oil has been extracted the remaining pulp often has some commercial use. The pulp left after the extraction of cotton-seed oil from the cotton seed is

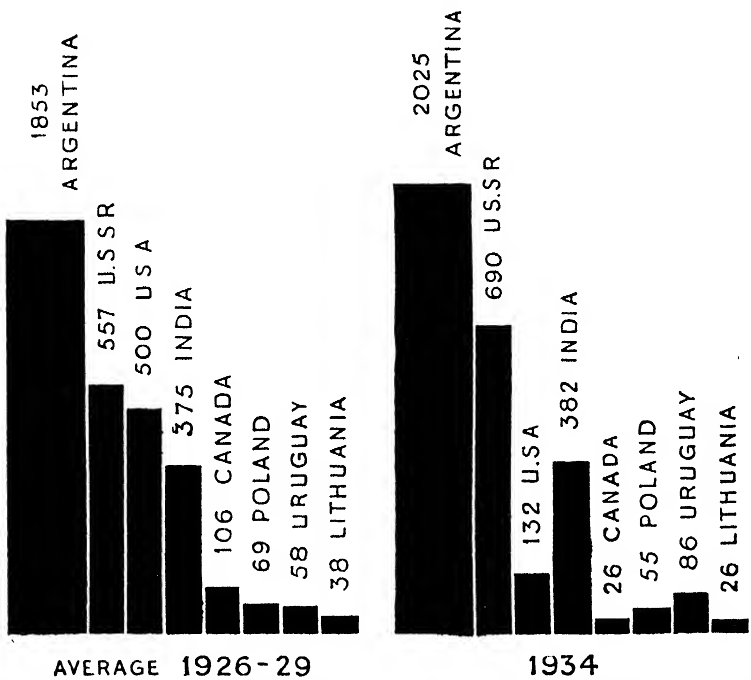


Fig. 161. World Production of Linseed in Thousands of Tons.

used for making oil cake for feeding animals. Linseed is similarly used.

Linseed Oil.—This, of great value in the making of varnish, is, as its name suggests, obtained from the seed of the flax plant (see page 305). Flax, grown for seed, is especially important in Argentina, and is also cultivated on the Deccan, and in Russia (Fig. 161).

Cotton-Seed Oil.—This is associated with the cotton-growing regions (see page 300).

SESAMUM OIL.—Sesamum oil, obtained from sesame or gingelly, is exported from India, West Africa, Egypt, and the Anglo-Egyptian Sudan.

SOY BEAN OIL.—The phenomenal rise in the soy bean trade is associated with the post-war exploitation and opening up of Manchukuo. The plant is indigenous to China, and has been cultivated there as a food crop for many centuries. In recent years it has been increasingly cultivated in the Ukraine region of South Russia.

OLIVE OIL.—The olive tree is the characteristic plant of Mediterranean countries, and where it has been introduced to "Mediterranean" regions outside Europe, the oil yield is less and the oil of poorer quality. The finest olive oil is produced in Italy (Lucca) and in the South of France. Algeria and Tunis are rapidly increasing their output.

GROUND-NUT OIL.—The ground-nut, more commonly known in England as the "monkey-nut" and in America as the "pea-nut," is most extensively cultivated in the savana areas of West Africa. It will thrive on light soils of little use for other forms of agriculture. The greatest output is from British West Africa (Nigeria, Gold Coast, Senegal, and Gambia), but it is also grown in the Southern U.S.A., Mexico, Argentina, India, China, and the Dutch East Indies.

CASTOR OIL.—This, principally important for its medicinal properties, is one of the many oil seeds cultivated in the Deccan of India.

PALM OIL AND PALM KERNEL OIL.—The Oil Palm is a native of West Africa. Nigeria, the Gold Coast, and Sierra Leone produce together 90 per cent. of the world's output, but the oil palm also grows in Brazil and some of the West Indies. In Malay, Sumatra, and Java, oil palm plantations have recently been established, and it will be interesting to see what the future holds for this industry (cf. rubber), for as yet there are no plantations in West Africa, all the palms growing wild in the forest. Beneath the outer skin of the fruit of the oil palm is a "pulp" containing some 60 per cent. of oil. Inside this pulp is the palm kernel which also gives a high yield of oil. Because the residual pulp is a

valuable food for animals, the palm kernels are usually exported whole, and the oil extracted in the country of importation. Palm oil is used extensively in the tin-plate industry of South Wales.

COCONUT OIL.—The coconut palm grows in hot, wet countries, and usually near to the sea. The dried kernel, known as copra, is exported from the East Indies and most of the South Sea Islands. Singapore and Sydney are the two chief collecting centres, whence the copra is dispatched to Europe. In addition, the coconut grows in the West Indies, and on the coasts of Brazil and East and West Tropical Africa.

There are, in addition to the above, many other plants which yield valuable oils, but they are produced in much smaller quantities.

Marseilles, Hamburg, and Hull are the most important European importing centres for vegetable oils, hence the industries in these ports are the refining of oil and the manufacture of margarine, candles, soap, etc.

CHAPTER XXI

THE POWER RESOURCES OF THE WORLD

Introductory

The three principal sources of power are coal, oil, and falling water. The latter has been utilised in modern times for the generation of hydro-electric power.

In 1913 nearly 90 per cent. of the world's power was obtained from coal, but in recent years there has been a rapid increase in the use of oil and electricity, and a relative decrease in the importance of coal.

Coal

The annual production of coal is over 1000 million tons. This includes anthracite, bituminous coal, and lignite (brown coal of poor quality), but excludes the production of peat, which is of considerable importance in Ireland, Holland, and the U.S.S.R. Coal is important not only as a source of power, but also for the production of gas, chemicals, fertilisers, perfumes, aniline dyes, and a vast range of other by-products.

The distribution of active coal production differs markedly from the distribution of coal reserves, for many vast coal-yielding areas have not yet been extensively developed. The coal reserves of China rank next to those of the U.S.A., but political difficulties have retarded their exploitation. Other large and almost untouched reserves occur in Central Canada, where the coal is of poor quality, and in Western U.S.A. (Utah) and Siberia, where communication is difficult.

The leading producers of coal (1934) are shown on Fig. 162. The United States, the leading producer, is responsible for about two-fifths of the total output. The bulk of the American coal comes from the great coalfields of the eastern half of the country, viz. Pennsylvania, Virginia, Kentucky, and Illinois.

Europe supplies about one-half of the total output, the chief countries being Britain and Germany. Because of the nearness of her coal-fields to the coast, Britain leads the world

as a coal exporter. The most notable increases in the production of coal in Europe in recent years have been in Russia, Poland, and the Netherlands.

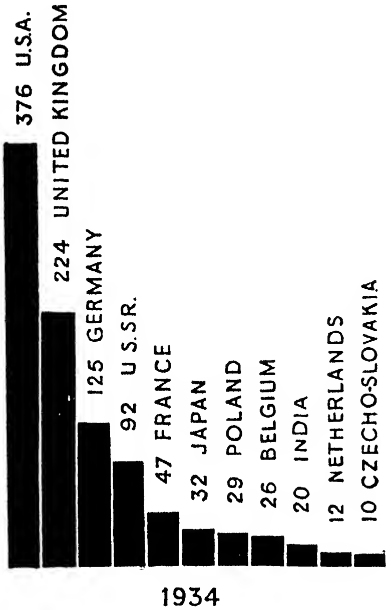


Fig. 162. COAL PRODUCTION 1934. Figures denote millions of tons.

The remainder of the world (*i.e.* excluding Europe with Asiatic Russia and North America) accounts for less than 10 per cent. of the total world production, and much of this comes from India and Japan. It will be clear, therefore, that the countries of the southern hemisphere are relatively unimportant as coal producers. The principal coal working areas of the southern continents are (*a*) in S. Chile near Concepcion; (*b*) in S. Africa (Newcastle, Middleburg, and Wankie); (*c*) in Australia (Newcastle, Ipswich, and Collie); and (*d*) in New Zealand (Westport and Greymouth). The fuller development of these coalfields, especially in Natal and New South Wales, in post-war years, has caused a considerable reduction in the export of British coal to these regions.

Mineral Oil

In 1850 very little petroleum was used, but to-day it is one of the "key products" of the world, being important for power, heating, lighting, and as a source of lubricating oils. Oil is rapidly replacing coal as fuel for ships. In 1931 more than one-quarter of the gross

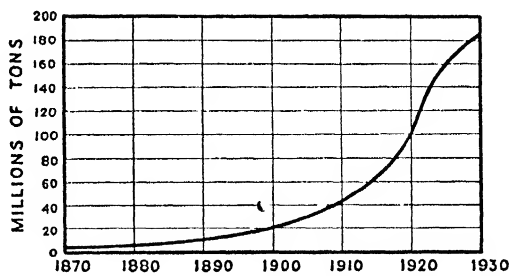


Fig. 163. OIL PRODUCTION.—Graph to show increase in oil production between 1870 and the present day.

tonnage of the shipping of the world was oil-driven. It has been estimated that the *Mauretania*, by using oil, saved 5000 tons of fuel on a trans-Atlantic trip, and that only 30 stokers were needed instead of 300.

Because of its great importance in transport and industry, the output of oil has increased with amazing rapidity (see Fig. 163), new fields are being opened up, and investigations are being made to assess the oil resources of the world. At

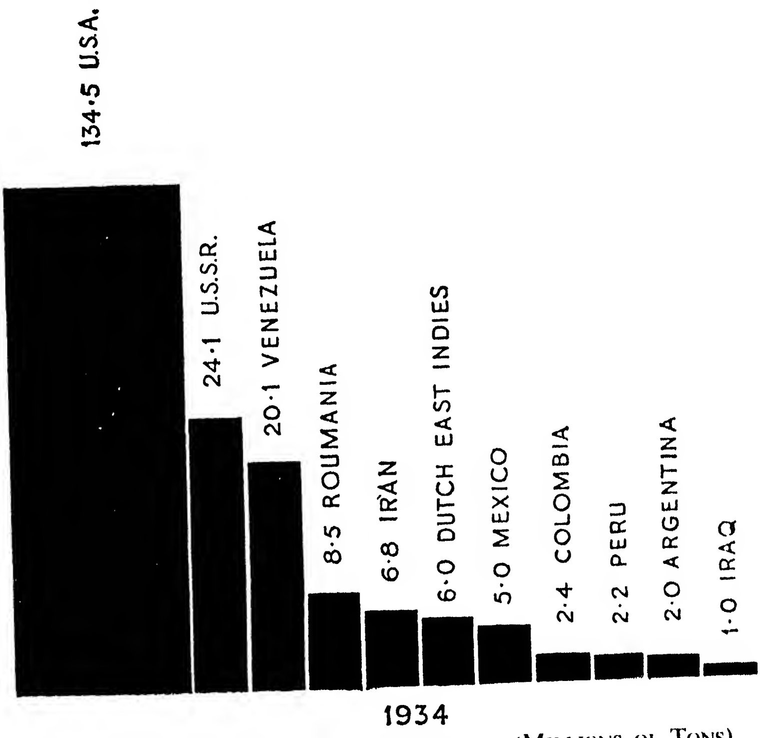


Fig. 163(*a*). PRODUCTION OF PETROLEUM (MILLIONS OF TONS).

present, however, the exploration of oil resources is so incomplete that no reliable estimates can be formulated.

The extraction of oil is an exhaustive industry. The opening of new fields may bring a country quickly into prominence as an oil-producer, but the supplies may last only for a limited period. For instance, in 1921, Mexico, producing 30 million tons of oil annually, ranked second only to the United States, but in 1934 Mexico produced less than 6 million tons, and ranked seventh as an oil-producing country.

The oil production of California has also decreased in recent years.

To-day, the U.S.A. is the leading producer of oil, being responsible for two-thirds of the world output, *i.e.* twice as much as all the other countries together. The chief oil centres of U.S.A. are in Texas, Oklahoma, Kansas, and California. More than 100,000 miles of pipe-line are used to carry the oil from the wells to the consuming areas and to the ports for export.

Russia is the second producer of importance. The Russian oilfields are situated at Baku (on the Caspian Sea), at Grozny and Maikop to the north of the Caucasus Mountains, and in the newly-developed fields along the western edge of the Urals. Pipe-lines connect Baku and Grozny with the Black Sea, and others are being constructed to link the Ural fields with the industrial areas.

Venezuela, where oil production is a very recent development, takes third place. The principal oilfields are in and around the Gulf of Maracaibo. It is fully expected that other rich oilfields will be found in S. America, especially along the eastern edge of the Andes.

The Romanian oilfield is situated near Ploesti on the southern edge of the Carpathians. There has been a large increase in the output during the post-war years.

The oilfields of Persia (Iran) are in the south-west of the country near Maidan-i-Naphtan. Deposits are also being worked further north on the borders of Iraq near Kirkuk. Oil from the latter fields is carried by pipe-line to the ports of Tripoli and Haifa on the Mediterranean coast. Other oil-producing countries are Mexico, the Dutch East Indies (Sumatra, Borneo), Burma, Peru, Patagonia, and Trinidad.

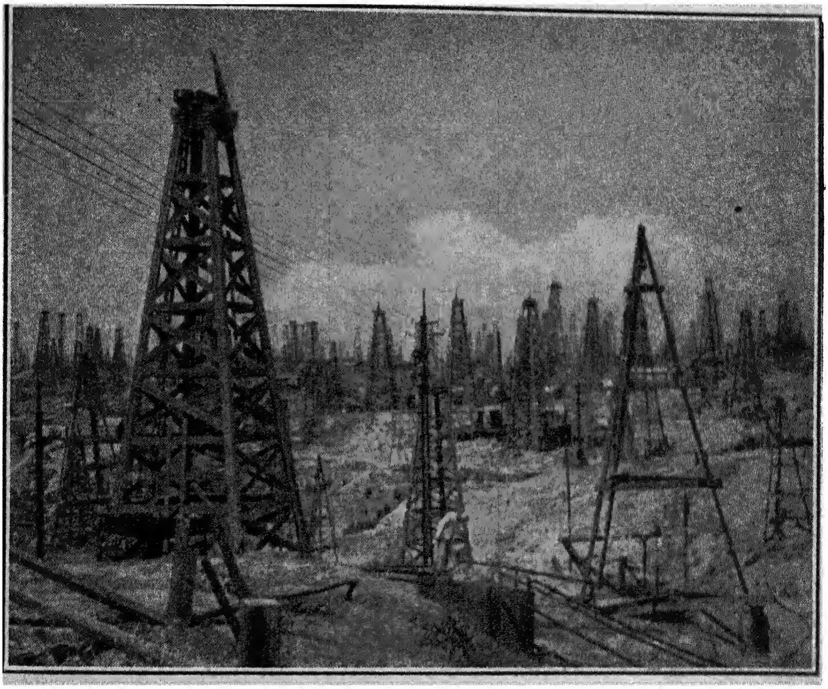
A careful study of the distribution of the oil resources of the world will show that in many instances they occur very near to the fold mountain systems.

Supplies of natural gas are also associated with the production of petroleum, but its use is almost entirely confined to the United States, where pipe-lines carry the gas from Texas to Chicago.

The distribution of oil in relation to the great shipping routes should be carefully noted. The Russian, Persian, and East Indian supplies are easily available for the Mediterranean-Suez route; the American supplies for the trans-Atlantic

routes; and the American, Mexican, and Venezuelan supplies for the Panama route.

Another point of interest is the distribution of oil in relation to the industrial regions. Of the four major industrial countries (viz. United States, Britain, Germany, and Russia), the United States and Russia have vast reserves of both coal and oil, while Britain and Germany have good supplies of coal but no oil deposits.



Burma Oil Co.

A FOREST OF OIL DERRICKS IN AN OIL FIELD AT YENANGYAUNG, UPPER BURMA.

It is for this reason that a continued search is being made for oil in Britain (*e.g.* near Portsmouth), and that attempts are being made to derive oil from coal.

Water-Power

The use of falling water for the generation of hydro-electric power is even more recent than the use of oil for power. At present, the use of hydro-electricity is confined almost

entirely to regions of advanced economic development (see Fig. 164). The natural conditions favourable to the development of hydro-electric power are:—

(*a*) Heavy rainfall evenly distributed throughout the year, so that the rivers will maintain a constant flow.

(*b*) An absence of very cold winter temperatures so that the rivers do not freeze.

(*c*) High mountains, so that the rivers will flow swiftly. Rapids and waterfalls are especially advantageous.

(*d*) Lakes, which act as reservoirs and help to maintain an even flow of the rivers.

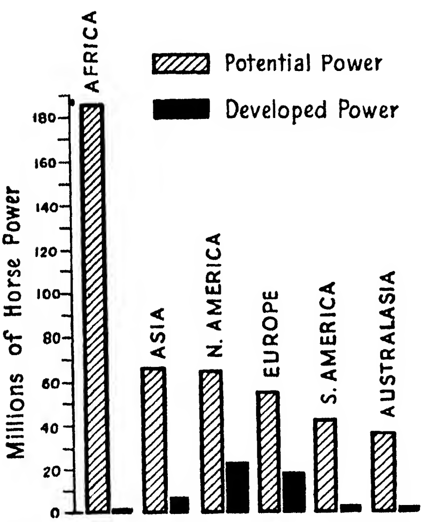


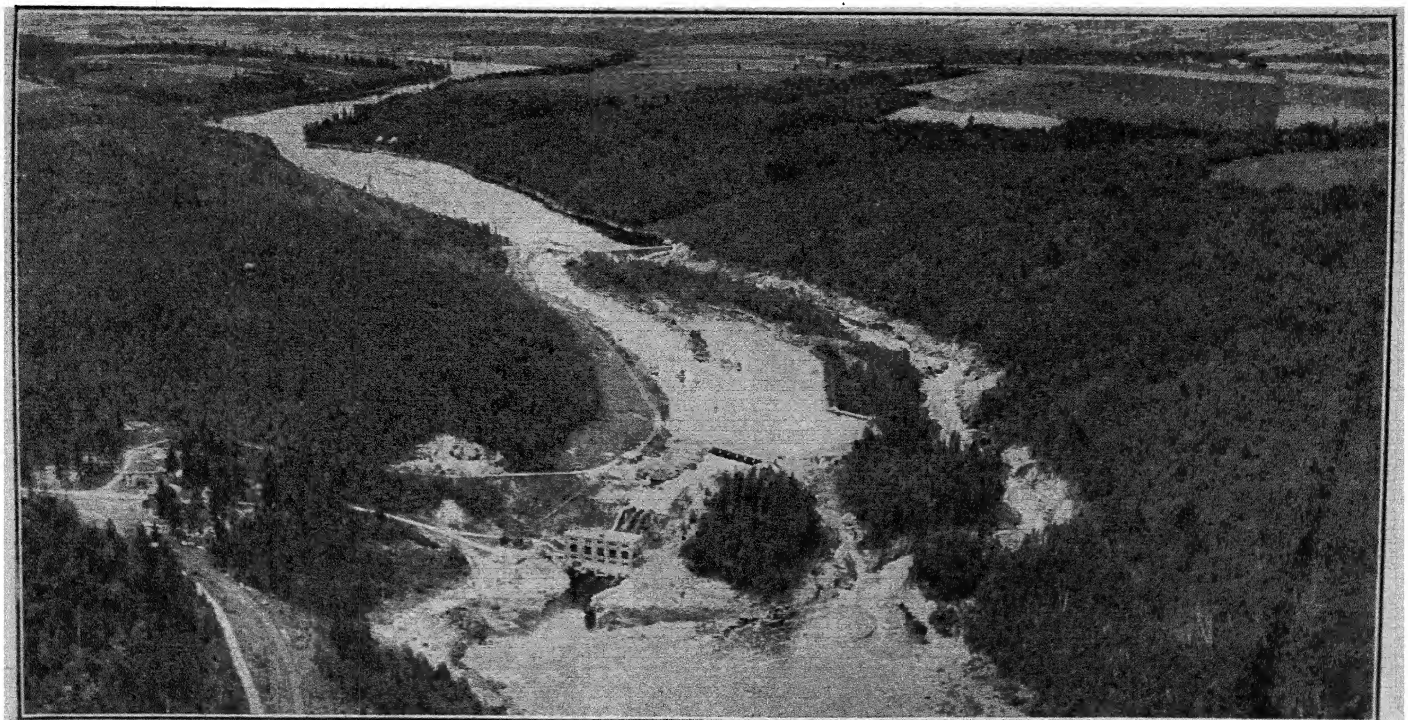
Fig. 164. Distribution of Water Power by Continents.

In many parts of the world these natural advantages are almost entirely unused. For instance, Africa, especially in the Congo region, possesses the greatest potential power resources of any continent, but they are practically undeveloped. In the future hydro-electric power may be used to exploit the vast mineral resources (copper, iron, phosphate, gold, asbestos, etc.) of this continent.

Next to Africa, Asia has the greatest resources of potential power. While considerable progress is being made in the southern mountains of Asiatic Russia, China has not a single hydro-electric plant, and the total power generated in the whole of Asia is less than that of Norway or Italy.

Other regions with great potential power resources are to be found in South America, in the Andes and along the edges of the Brazilian and Guiana plateaux.

More than 95 per cent. of the total output of hydro-electric power is concentrated in North America and Western and Central Europe, though the greatest single centre in the world is at Dnieprostroi on the river Dnieper in S. Russia.



Royal Canadian Air Force Photo

WATER POWER. AROOSTOOK R., NEW BRUNSWICK.

Note the manner in which the rock bar crossing the river is used as the site for the power plant. The slopes of the valley are also clothed with woods, which are important in regulating the surface drainage.

The principal countries in which hydro-electric power is used are United States, Norway, Newfoundland, Canada, Switzerland, Sweden, Italy, France, Russia, New Zealand, Japan, Chile, Germany, Brazil, and Britain. Many of these countries, viz. Norway, Sweden, Switzerland, and Italy have practically no coal and use electricity as the basis of their industrial development. Based on the *per capita* consumption, Norway, Canada, and Switzerland are by far the most lavish users of electricity, but the United States has actually a greater output than any other country.

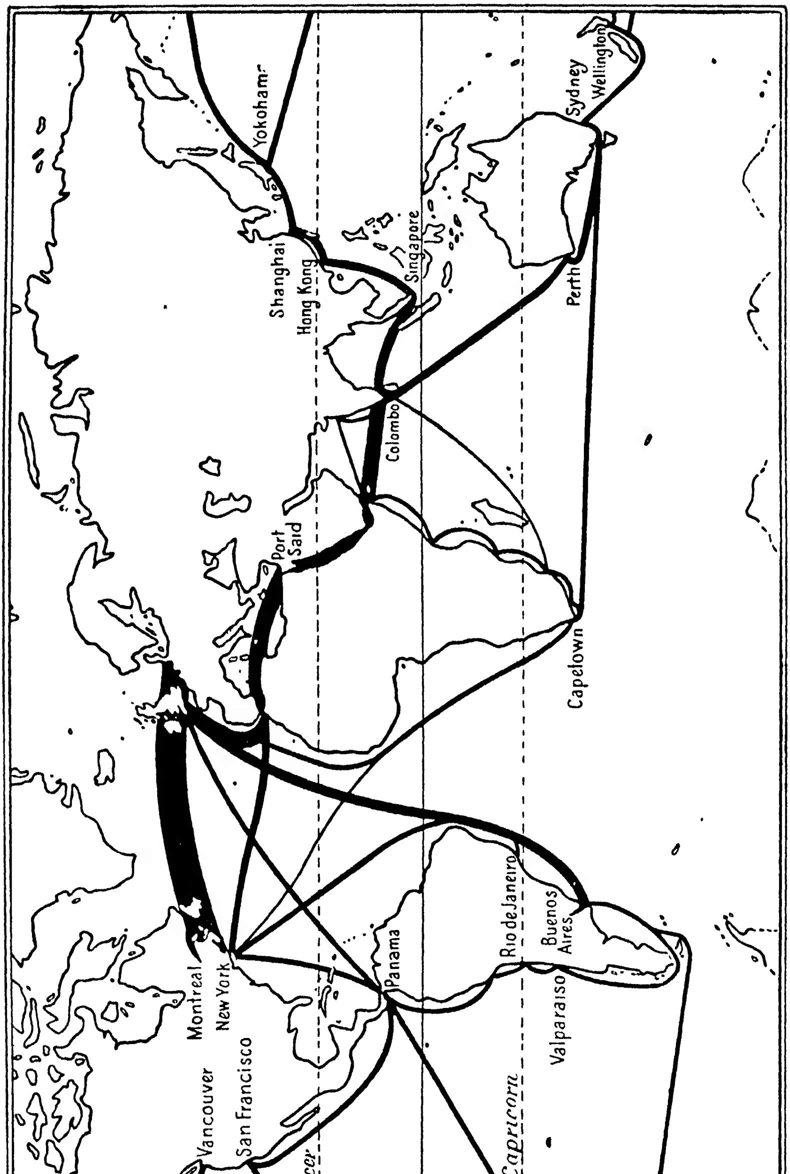
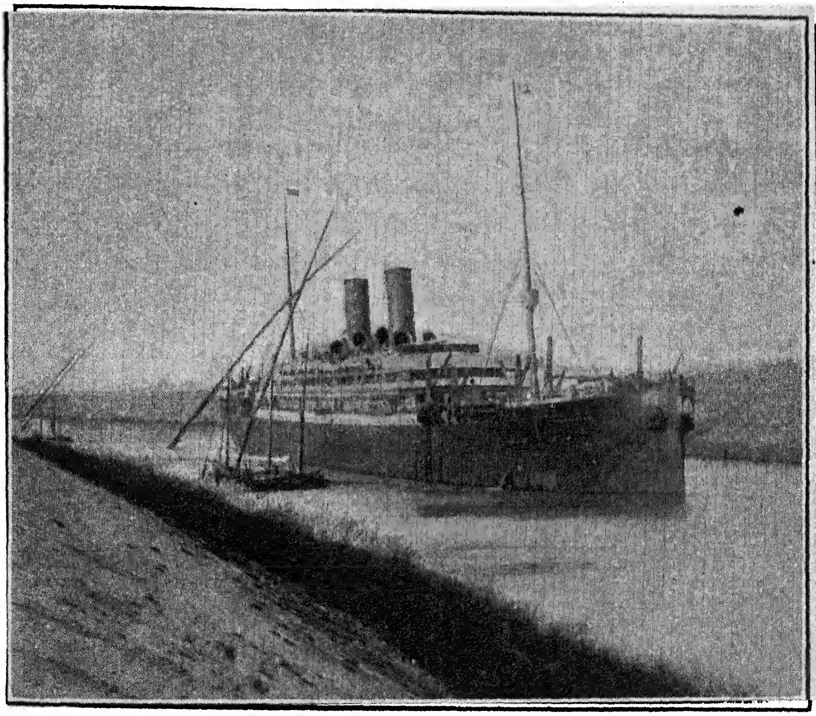


Fig. 165. The Chief Ocean Routes of the World.

there is little scope for interchange and trade. The trading associations of these two areas are with Europe and America, where they can sell their surplus food and raw materials, and whence they can obtain manufactured goods.

The Mediterranean-Suez Route

The map of world trade routes shows that the Mediterranean-Suez route to the East, to Australia, and to East Africa ranks



Suez Canal Co.

THE SUEZ CANAL.

The sides of the canal are composed of sand on which grows coarse grass. The width of the canal is not great enough for large ships to pass except in specially widened sections. All ships proceed slowly through the canal so that the wearing away of the banks is reduced as much as possible.

next in importance to the North Atlantic route. This great route passes through the heart of the Old World, and ships following it can call at more ports and serve more peoples than on any other route. There are a large number of re-fuelling stations, viz. Gibraltar, Malta, Port Said, Aden, and

Colombo, so that ships can coal or oil frequently and thus carry more cargo. The Suez Canal limits the size of ships on this route, so that the eastern shipping companies do not compete with the North Atlantic lines in the construction of big vessels. Practically all the European and much of the American traffic for India, the East Indies, China, and Japan passes through Suez.

The outward traffic to Australia through Suez is principally that of passenger and mails. The Suez tolls are high, therefore cheaper fares, both for emigrants and goods, make the Cape route the most important for trading ships going out to Australia. These fuel at Capetown and proceed to Australia backed by the strong west winds of the south temperate zone. Sailing ships always use the Cape route to Australia, and take advantage of the westerlies in the South Indian Ocean. Ships returning from Australia follow three routes:—

(1) Sailing ships proceed westwards across the South Pacific, and, backed by the westerly winds, reach Europe via Cape Horn and the Atlantic Ocean. Such is the route used by the annual race of grain-carrying sailing ships.

(2) Some ships travel back from Australia via South Africa. Then they take a route slightly more northerly than on the outward journey, in order to avoid steaming in the teeth of the westerly winds. These ships usually coal at Durban, where coal is cheaper than at Capetown.

(3) At least 50 per cent. of the homeward-bound ships from Australia return via Suez. The products which they carry, principally wool, wheat, and meat, are sufficiently valuable to go by the shorter but more expensive route.

The Routes of the Pacific Ocean

The sea routes of the Pacific are of much more recent origin than the others already described. There is a route from western North America to China and Japan which is in some ways a parallel to the North Atlantic route. Raw silk and tea from Japan and sugar from Hawaii are carried eastwards to America, the return cargo being mainly timber and manufactured goods, and in recent years food products also. The Pacific routes converge on four main points: (1) Western America (Vancouver and San Francisco); (2) Panama;

(3) China, Japan, and the East; (4) Australia and New Zealand.

An important feature of the Pacific routes is the use of the Panama-New Zealand route for fast passenger traffic from the east of U.S.A. and from Europe. As in the South Atlantic, there is no really important east-west route in the South Pacific, because Australia and South America have few goods to interchange.

The two great east to west ocean routes of the northern hemisphere form part of a " girdle " of land and sea routes, viz. north-west Europe to eastern America by sea; eastern America to western America by transcontinental railways; western America to eastern Asia by sea; eastern Asia to Europe by the Trans-Siberian railway. There is no counterpart of this "girdle" of routes in the southern hemisphere (see page 332).

Panama v. Suez

Before the opening of the Panama Canal America's shortest sea route between the ports of her eastern and western coasts was via Cape Horn. Ships sailing from ports of N.W. Europe to the west of South America had to take a similar course. The opening of the Panama Canal has benefited the American ports and trading facilities considerably, and the ports of western Europe have benefited also, but to a lesser extent.

The main results of the opening of the canal are summarised below:—

(1) The route from *England to New Zealand* is slightly shorter by Panama than by Suez, but the route to Sydney is shorter via Suez. The Suez route has the advantage of touching more countries and having therefore greater advantages in respect to the collection both of cargo and passengers. The Panama route to New Zealand is therefore used primarily for quick mail and passenger transport.

(2) Although Panama does not shorten the route from *England to Australia*, it does shorten the route from the ports of Eastern America to Australia.

(3) The ports of *Eastern Asia* are still nearer to European ports via Suez, so that in this respect the Suez route is not

affected. However, all ports from Hong Kong northwards and eastwards (*e.g.* Shanghai, Manila, Yokohama) are nearer to New York via Panama than by Suez. Therefore much American trade to the Far East is not carried via Panama, for American ships trading with India and Asiatic ports west of Hong Kong will use the Suez route, both because of the lesser mileage and because of the greater trading facilities the Suez route offers.

(4) The *western seaboard of both North and South America* is brought nearer to the ports of both eastern America and western Europe. This is one of the greatest advantages of Panama, since it has helped to develop the trade of the western states of South America. British Columbia now exports grain, timber, and other bulky commodities by a cheap "all-water" route instead of by the expensive trans-continental route as before.

(5) As far as *the United States* is concerned the greatest advantage lies in the shortening of the sea route between her eastern and western coasts not only for trading purposes but for strategic reasons. The ships of the American navy can now be moved much more quickly from the Atlantic to the Pacific and vice versa, as political needs demand.

(6) The use of the Panama route will have a beneficial effect on the *West Indies* which now lie on a great ocean highway, instead of being, as formerly, the terminus of a sea route.

AIR ROUTES

A natural limit is set to the length of great land and sea routes by the extent of the continents and oceans. It would appear at first that there is no such natural limit to air routes. In practice, however, the same geographical features which add to the difficulty of land routes, have considerable effect on the choice and planning of those air routes which can be of real commercial value. The chief dangers of air travel are those of forced landings. Therefore air routes are planned so that they avoid:—

(*a*) Large stretches of ocean. Air routes take the shortest sea crossings, as far as possible, even though it means a lengthened route, keeping to the land and to chains of islands.

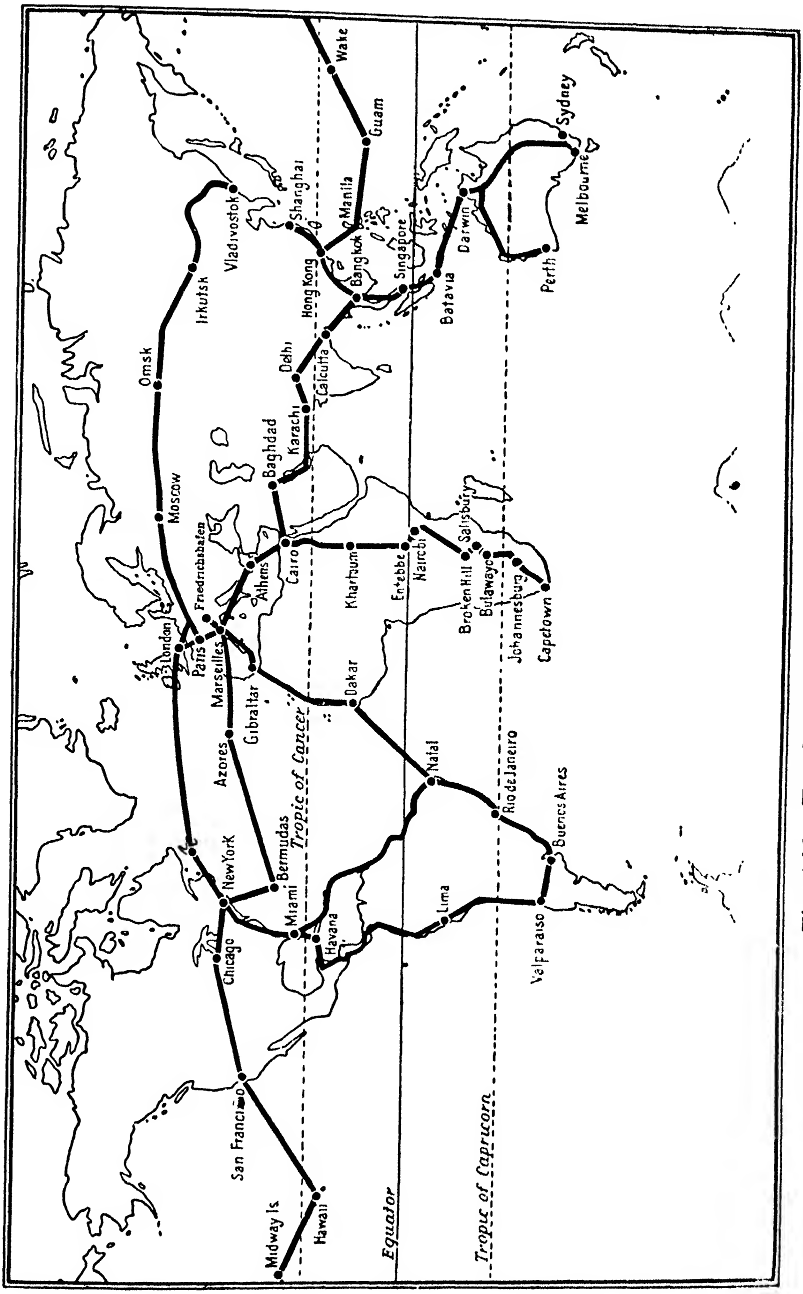


Fig. 166. The Principal World Air Routes.

(*b*) Extensive areas of desert land which provide little food and no facilities in the nature of repair depots and petrol supplies.

(*c*) High mountain areas where complicated air currents make flying dangerous; where landing conditions are difficult; and where aeroplanes may be forced down under the weight of ice on the wings.

(*d*) Extensive forest areas where landing is obviously difficult.

Thus those very barriers which impede man's progress on land are effective in limiting his choice of air routes.

Over the land masses of Europe and North America there are now networks of airways linking all the important cities. It is impossible to analyse these in detail, but one example may serve to show how air travel has developed in recent years; *e.g.* Berlin has regular air services to Amsterdam, Copenhagen and Oslo, Danzig, Warsaw and Moscow, Budapest, Vienna, Berne, Paris, Brussels, and London, and to many other European cities.

Apart from the continental networks of airways there are many great and spectacular world airways of special interest, viz :—

(1) England to the East and Australia.

(2) England to Capetown.

(3) North-Western Europe to Buenos Aires.

(4) Buenos Aires to New York.

(5) San Francisco to the Philippines and Eastern Asia.

(6) Western Europe to Eastern Asia via Siberia.

(7) The North Atlantic Route.

1. England to the East and Australia

It should be noted that the established commercial route is not always identical with that followed by pilots in air races. This route is from London to Paris and thence to Marseilles, following the Rhone corridor and avoiding the high Alps. From Marseilles aeroplanes fly to Athens and Alexandria, a great air port and air junction, for at this point air routes

diverge to the East and southwards to Capetown. From Alexandria the route goes east to Amman in Transjordania, and thence to Baghdad and Basra. The slight northward detour to Baghdad avoids large stretches of the Arabian Desert.

From Basra, the route avoids the barren mountains of Iran (Persia) and follows the coast to Karachi. Thence, partly attracted by the populous centres of the Indo-Gangetic plain, and avoiding the Deccan plateau lands, it proceeds via Delhi and Allahabad to Calcutta. The route then follows the Burmese and Siamese coasts to Rangoon. From Rangoon, the aeroplanes go to Bangkok (whence there are air routes to South China and Japan), and thence to Singapore, following the coast of the Malay Peninsula. From Singapore, the Australian route follows the chain of East Indian islands to Keepang at the south-west end of Timor. The crossing of the stormy and shark-infested Timor Sea between Keepang and Port Darwin is unavoidable. From Darwin there are two important routes.

(*a*) South and south-east across the Australian lowlands to Brisbane, Sydney, Melbourne, and Adelaide, and

(*b*) Along the north and west coasts of Australia to Perth.

2. England to Capetown

This route is identical with the Australian route as far as Alexandria. From Alexandria the route follows the Nile Valley and the African grasslands to Aswan, Khartoum, and Entebbe (on Lake Victoria). Thence it proceeds eastwards to Nairobi and southwards, still following the grasslands, to Broken Hill, Salisbury, Bulawayo, Johannesburg, and Capetown.

This route serves the British African colonial areas and avoids the great stretches of desert and forest land that would have to be crossed by a more westerly route.

3. North-West Europe to Buenos Aires

This is the route over which there have been regular flights by the Graf Zeppelin. The chief difficulty is the crossing of the South Atlantic. Aeroplanes on this route first go to Marseilles and hence follow the Spanish coast to Gibraltar. After leaving Gibraltar they follow the African coast to

Dakar near Cape Verde in Senegal. From Dakar, they take the shortest sea crossing to Port Natal near Cape San Roque in Brazil, and then follow the South American coast to Rio de Janeiro and Buenos Aires.

This route is of great importance owing to the increasing commercial relationship between Brazil, Argentina, and North-West Europe.

4. Buenos Aires to New York

There are two important routes from Buenos Aires to New York :—

(*a*) The first route follows the South American coast northwards to Port Natal, and then turning north-west follows the coast of Brazil and the Guianas to Trinidad. The island festoon of the Lesser Antilles provides the route to the larger West Indian islands, Haiti and Cuba. From Cuba the route goes to Florida and along the American east coast plains to New York.

(*b*) The second route from Buenos Aires to New York is more westerly. Aeroplanes first cross the Argentine lowlands westwards to Mendoza. Here they must await a signal that the weather conditions are suitable for the difficult crossing of the Andes via the Uspallata Pass. From Valparaiso, the route follows the coast very closely to Panama, and thence along the isthmus of Central America, Yucatan, Cuba to Miami in Florida, and thence along the eastern lowlands of the United States to New York.

5. San Francisco to Eastern Asia

This route entails the crossing of vast stretches of ocean, and so uses all the available islands. Therefore this route is via Hawaii, Medway Island, Wake, and Guam to Manila in the Philippines. From Manila, air routes diverge to various Eastern Asiatic ports.

An alternative route, and shorter because of its closer approximation to the " great circle route," would be northwards along the North American coast and the Aleutian islands, and south-westwards along the Asiatic coast. This route would, however, pass through the bad weather and gales of the westerly wind belt.

6. Western Europe to Eastern Asia

The air routes between Western Europe and Eastern Asia via Siberia, follow very closely the line of the Trans-Siberian railway. From it a number of other routes are used for transport into those parts of Asia which have no railway and little road development.

7. The North Atlantic Route

The latest world air route to be developed is that across the North Atlantic. The first regular services were made by the German airship Hindenburg in 1936, and arrangements are being made for probable British services in 1938. On the direct route weather conditions often are bad. If a more southerly route were selected in the latitudes of better weather conditions it would be too long, especially as there is a lack of islands to provide calling stations.

TRANSCONTINENTAL RAILWAYS

Among the major routes of the world must also be included the great transcontinental railways, the fuller details of which should be studied in the regional geography of each continent. The chief function of these railways is to provide quick transport across the continents from ocean to ocean. Since carriage by land is more expensive than carriage by sea, transcontinental railways are rarely used for the "through" transport of bulky commodities, though such goods (*e.g.* wheat, metal ores, etc.) are carried by rail from the producing regions to the coast. Through traffic on these routes is mainly concerned with the transport of passengers, mails, perishable goods, and articles of high value and small bulk.

In the northern hemisphere, the transcontinental railways are an integral part of the great east to west "girdle" of communications (see page 332). There is no counterpart of this girdle of routes in the southern hemisphere, for

(1) The continents are narrower.

(2) Most of the really important ocean routes lead northward to the densely populated areas of Europe and N. America.

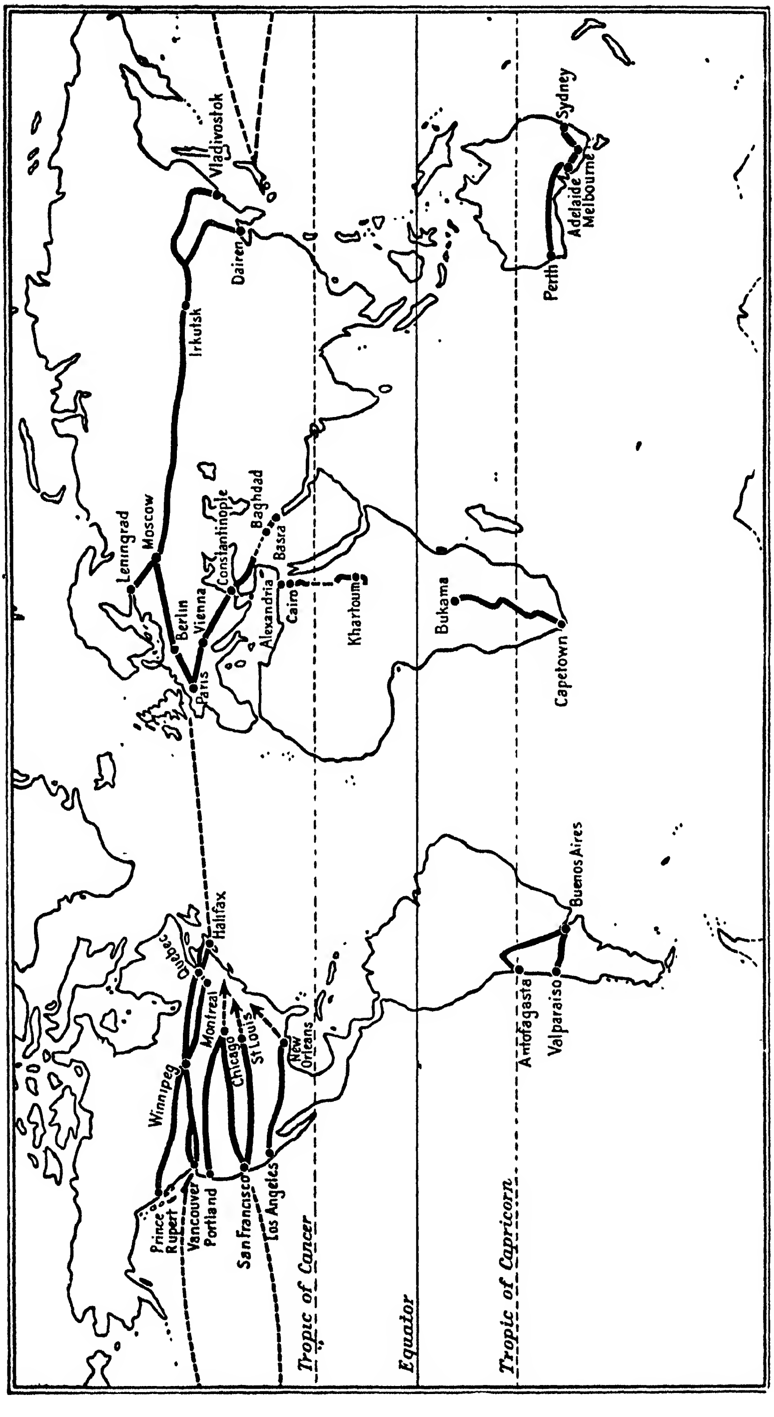


Fig. 167. TRANSCONTINENTAL RAILWAYS WITH NORTHERN SEA ROUTES INDICATED TO SHOW THE "GIRDLE" OF COMMUNICATION IN THE NORTHERN HEMISPHERE.

(3) There is little trade between S. America, S. Africa, and Australia because of the similarity of their productions.

North America

In North America there are several railways crossing the continent from east to west. Though they are all referred to as "Transcontinental Lines," those of the United States lose their identity as such to the east of the Mississippi, where they merge into the railway network of the eastern U.S.A.

The principal transcontinental routes of N. America are:—

A. CANADA.—(1) The Canadian Pacific Railway, completed in 1885, which was primarily built to link British Columbia with the eastern provinces of Canada. It joins Halifax and St. John's with Montreal, Winnipeg, Regina, and Medicine Hat, at which point the main line divides. One branch proceeds via Crow's Nest Pass to Vancouver and the other via the Kicking Horse Pass and the Frazer valley to Vancouver.

(2) The Canadian National Railway which links Moncton, on the Bay of Fundy, with Quebec, and thence takes a more northerly route than the C.P.R. to Winnipeg. From Winnipeg it proceeds to Edmonton, and thence via the Yellowhead Pass to Prince Rupert and Vancouver.

B. THE UNITED STATES.—(1) The Great Northern Railway, linking Duluth and Seattle.

(2) The Northern Pacific Railway, which joins Chicago, St. Paul, Bismarck with Tacoma and Portland.

(3) The Union Pacific Railway, running from Chicago to Omaha, Ogden, and San Francisco.

(4) The Santa Fé Railway, which links St. Louis, Kansas City, Santa Fé, and Los Angeles.

(5) The Southern Pacific Railway, passing from New Orleans to Los Angeles.

The North American transcontinental railway routes provide quick transport between the Atlantic and Pacific coasts, and were of very much greater importance before the opening of the Panama Canal, which provided a cheap water

route between the two coasts. The railways are primarily concerned with passenger and mail traffic. The chief goods carried across the continent are fruit and films from the western states eastward, and manufactured goods of high value westward. Such commodities as raw silk and tea from the East also form part of the eastbound merchandise.

Eurasia

The two outstanding transcontinental routes of Eurasia are :—

(1) The Orient Express route, which links Paris, Vienna, Belgrade, and Constantinople (Istanbul). It has been continued across Asia Minor and will ultimately provide a through route from Paris to Basra on the Persian Gulf. This railway will provide very quick communication between the densely populated lands of south-east Asia and north-east Europe.

(2) A great west to east route which follows the lowlands of central Europe and northern Asia from Paris to Vladivostok. The western portion of this route runs from Paris, through Cologne, Berlin, and Warsaw to Moscow. The eastern section, known as the Trans-Siberian Railway, runs from Leningrad and Moscow across the Siberian lowlands to Vladivostok. This railway, completed in 1905, was constructed primarily to provide quicker communication between the centre of government in European Russia and the remote and isolated Russian territories bordering the Pacific.

While it has been of undoubted value in helping to open up the isolated areas of Central Siberia, its value as a " through route " must not be over-estimated. Like the American transcontinental railways, its through traffic is practically confined to the transport of passengers, mails, and urgent or valuable goods. Bulky goods can be more cheaply carried by the Suez route.

South America

The chief transcontinental railway of South America is that linking Buenos Aires and Valparaiso. It gives quick communication between these two cities as compared with the long and stormy sea route via the Straits of Magellan.

A second route runs from Buenos Aires north-westward to Tucuman and thence across the Bolivian plateau to Antofagasta in North Chile. It is extremely doubtful whether this route will ever be of much importance for "transcontinental" traffic.

Africa

The still uncompleted Cape to Cairo railway is an impressive enterprise originated by Cecil Rhodes. Its aim was to link the railways of Egypt and the Sudan with those of South Africa. Unlike the Trans-Siberian Railway it does not tap vast and remote landlocked areas, but is paralleled by cheaper sea routes both on the east and west. Its main function, to-day, seems to be to link the termini of shorter lines running inland from ports on the east and west coasts. Its terminus, Capetown, is not the beginning of other important routes by sea, and so is virtually a "cul de sac." Little merchandise is carried between Johannesburg and Capetown, for the majority of ingoing and outgoing goods use the lateral railways to Lourenço Marques or Beira.

Australia

A spectacular transcontinental railway, crossing over 1000 miles of desert, links South-East Australia with Perth in Western Australia. This railway was built by the Australian Government so that West Australia could be more closely linked with the other states for political purposes. Like the Cape to Cairo railway it is paralleled by a sea route, and so has little goods traffic. Another transcontinental line, part of which has been constructed, will link Darwin with Adelaide, and so reduce the isolation of the Northern Territories from the rest of the Commonwealth.

CHAPTER XXIII

WORLD DISTRIBUTION OF POPULATION

Some Factors Affecting the Distribution of Population

A map showing the density of population throughout the world reveals the fact that human beings are very unevenly spread over the earth's surface. Most people congregate where natural and other conditions most easily provide a means of earning a livelihood, and they shun those areas which present difficulty in so doing. Relief, climate, vegetation, and accessibility all help to limit man's activities. The *tundra* is too cold and remote, and is only inhabited by scattered tribes of nomads. *Forest* regions, both in the temperate and hot zones impose limitations on settlement, and are usually only inhabited by scattered groups of trappers and lumberers in the temperate zone, and by wandering, half-civilised hunting tribes in the hot, wet parts of the globe.

Hot deserts, too, are scantily peopled, unless mineral wealth lures adventurous seekers to settle in spite of the shortage of food and water, as in the deserts of Western Australia and in the inhospitable climate of the Yukon goldfields. Irrigation schemes make the cultivation and settlement of limited areas of the deserts possible, as in Egypt, Mesopotamia, portions of the deserts of western U.S.A., and the fertile river valley strips of the Peruvian Desert.

Mountains, except where mineral wealth attracts, or where they provide cooler conditions as a relief from the heat of the neighbouring plains, are scantily peopled because of their ruggedness, unfavourable climate, difficulties of transport, and the limitation placed upon agriculture. Inaccessible plateaux like Tibet have few people, but on the other hand, the cool plateaux of the Andes (Peru, Ecuador, etc.) have a greater population than the hot forested plains of the Amazon.

The regions of densest population in the world are either regions of great industrial development, or regions of intensive and scientific agriculture.

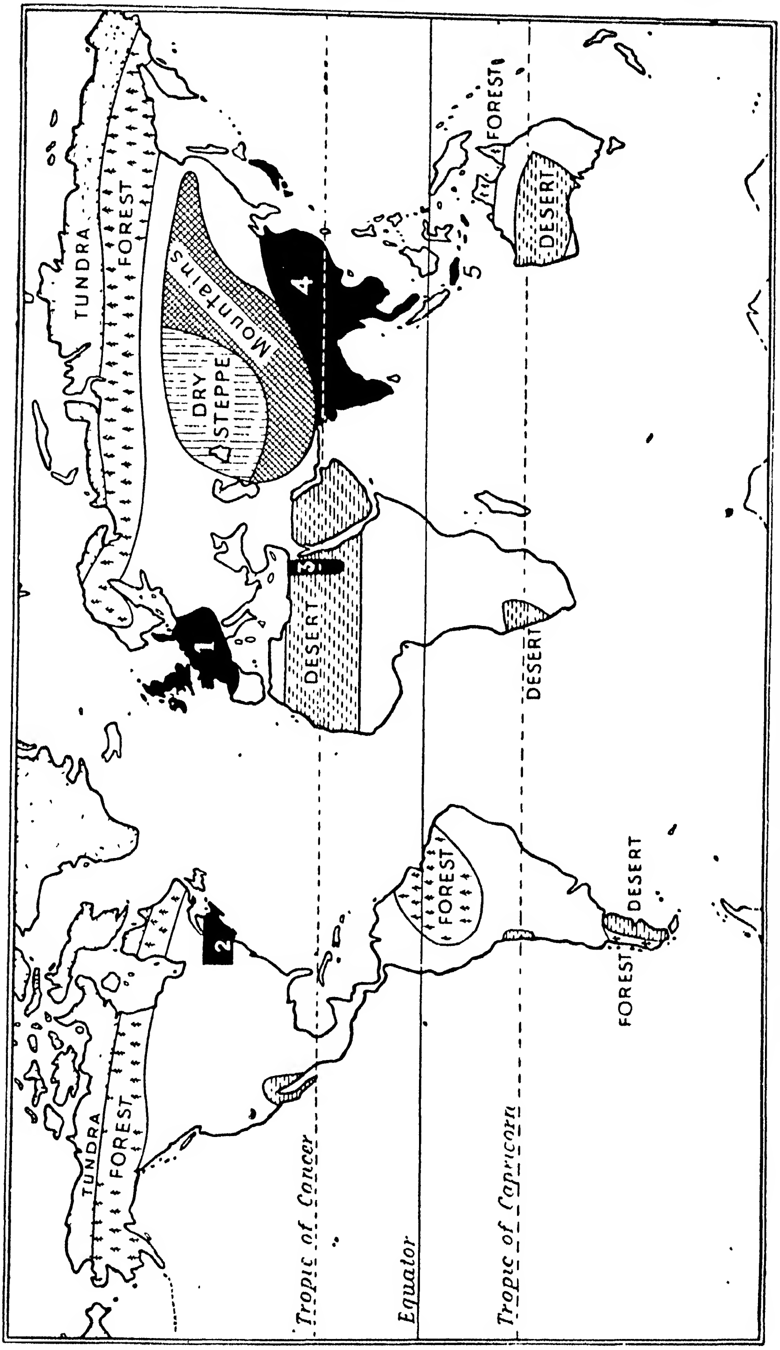


Fig. 168. World Regions of Dense and Scanty Population.

Manufacturing Areas

In this and the following section the numbers (1) to (5) refer to Fig. 168 on page 337.

(1) The greatest manufacturing region in the north-west of Europe, which includes the highly industrialised areas of Britain, Belgium, north-east France, and Germany. The densest population is found on the coalfields. Agriculture in these regions is also of an intensive and scientific type. Belgium, with more than 700 people per square mile, is the most densely populated country in Europe. The northern plain of Italy, intensively cultivated, and with many large industries using hydro-electric power, is another European area of dense population.

(2) Another great manufacturing region with a dense population is in the north-east of U.S.A., a belt extending from Chicago eastwards, south of the Great Lakes, through the Pennsylvanian coalfield to New York and the New England States.

Densely Populated Agricultural Areas

Regions with a very dense population dependent on agriculture are:—(3) Egypt, (4) the south-east of Asia, (5) Java.

Egypt is densely populated along a narrow strip on both sides of the River Nile. This is an oasis land where the possibility of two and three crops per annum as a result of climatic and soil conditions gives a high agricultural return, and consequently supports many people. Moreover the Nile Valley is a region of long historical development.

In the countries of south-east Asia, viz. Japan, China, India, Siam, and French Indo-China there are both densely and sparsely peopled regions. The alluvial river basins, viz. Ganges, Si-Kiang, Yangtse, etc., are all thickly peopled, but mountainous zones and dry areas such as the Thar Desert support very few people.

Java, an island in the equatorial zone, with well organised plantations and a rich volcanic soil, is the most densely peopled area in the world, with 785 people per square mile.

CHAPTER XXIV

TOWN SITES

The Influence of Rivers

People tend to congregate at the meeting-place of natural routes. Also one of man's main considerations in making a settled home was a good water supply. Remembering that river valleys are nature's "easy ways" or routes across a country, the most likely place for man to settle was by a river, because here he had both water supply and ease of communication.

Most of the "old" towns of the world are situated by rivers, though many of the larger towns are not, for they have grown up on coalfields during the industrial development of the last century.

Some river situations have more advantages than others, and the more important types of river sites are enumerated below.

(1) The confluence of two rivers. Here three valleys meet and a town develops, *e.g.* Coblenz (Lat. *Confluens*), where the River Lahn and the River Moselle join the Rhine; Oxford, at the confluence of the Cherwell and the Thames; St. Louis, at the confluence of the Mississippi and Missouri; Khartoum, at the confluence of the Blue and the White Nile; Allahabad, at the confluence of the Jumna and Ganges; and Hankow (kow = mouth), at the confluence of the River Yangtse-kiang and the River Han.

(2) The bend of a river, *i.e.* where the river changes its direction, *e.g.* Sheffield (Don), Orleans (Loire), Kaifeng (Hwang Ho), Stalingrad (Volga).

(3) The lowest bridging point, which is often the head of the estuary and the limit of ocean navigation, *e.g.* London, Rouen, Hamburg.

(4) A ford, which is a place where the river is shallow enough to be crossed without difficulty, *e.g.* Bedford, Worcester.

(5) The limit of navigation. London Bridge is the limit of navigation for ocean vessels, as is Hankow on the Yangtse-kiang. Oxford is the limit of navigation of the Thames by river steamer; Bedford is the limit for small river craft on the Ouse. In Roman times York was the limit of navigation on the York Ouse for grain-carrying vessels.

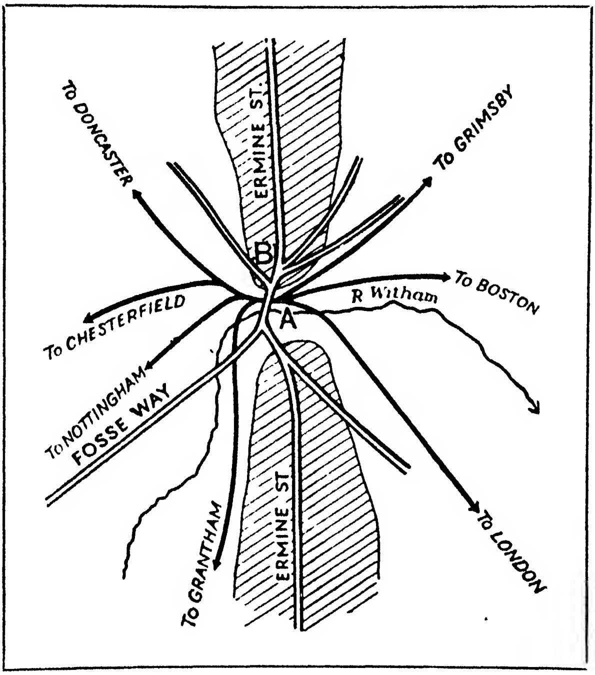
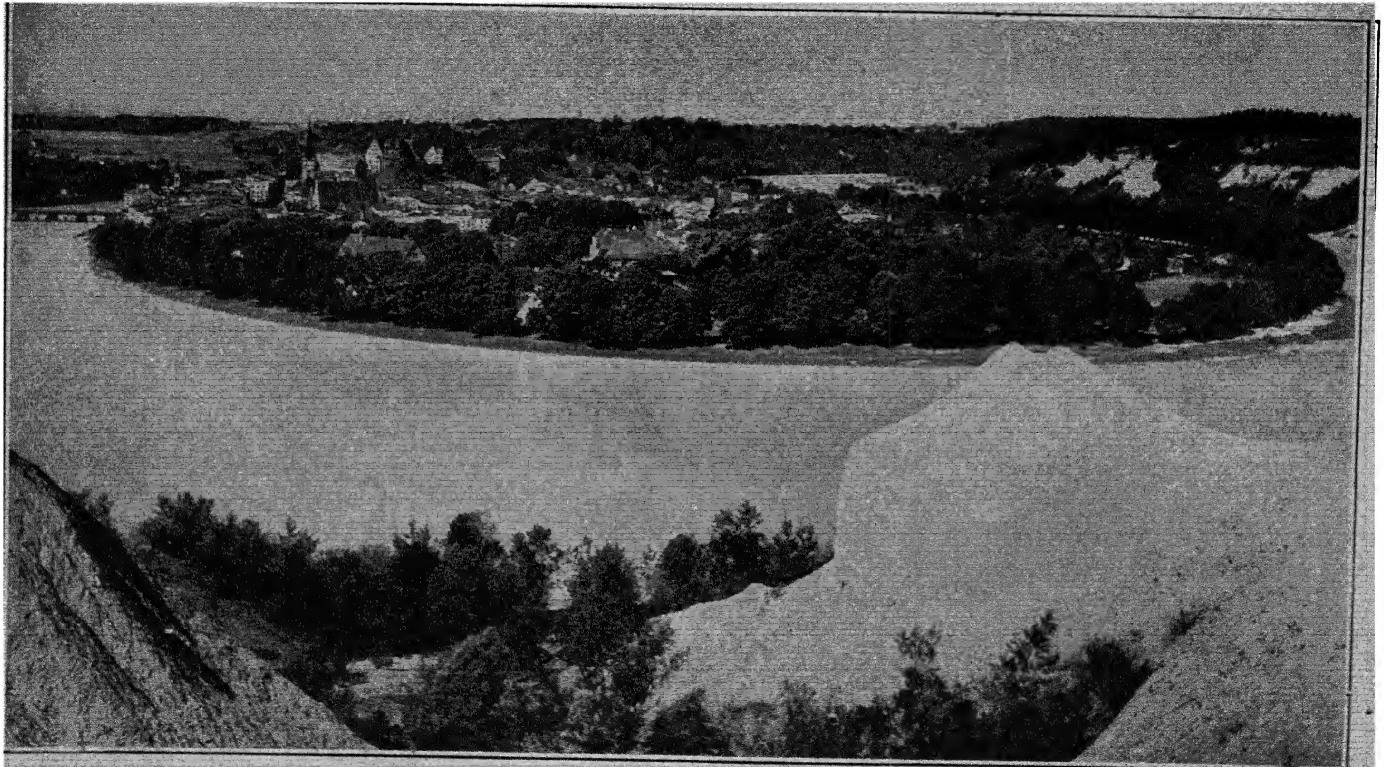


Fig. 169. LINCOLN.—Shows the convergence of routes on a gap. The shaded portion is the Lincoln Edge (limestone) through which the R. Witham cuts a gap. Double lines are roads and single lines are railways. Note how the old Roman road, Ermine Street, keeps to the unforested hill tops. The old part of Lincoln with its cathedral, markets, etc., are in the high area B. Railway station and factories in lower region A.

(6) Where a river flows through a ridge of hills, *i.e.* a gap. Routes converge on such points just as they do on river bridges, *e.g.* Lincoln (Fig. 169), Guildford, Rheims, Toulouse, Mukden.

(7) Where a river enters or leaves a gorge. A gorge differs from a gap mainly in its length, *e.g.* Ironbridge, where the Severn enters its gorge, and Bridgnorth, where it emerges



German State Railways

WASSERBURG.

This picture shows a small town built on an area of flat land within a river loop.

from the gorge; Bingen and Bonn, on the Rhine; Linz and Vienna, on the Danube; Ichang and Wanshien on the Yangtse-kiang.

(8) Where a river leaves the narrow valley of the hills for the broad open plains. This is a point at which the hill

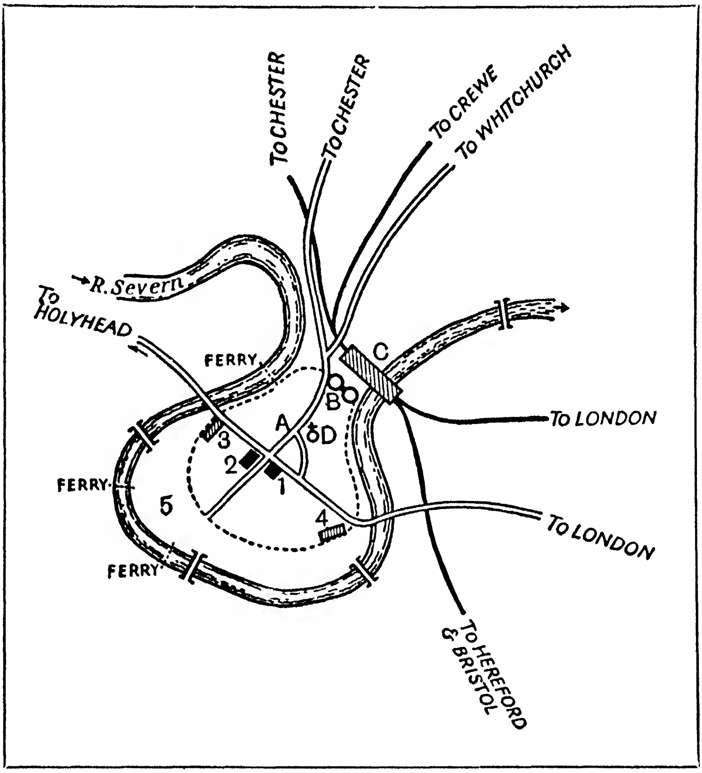


Fig. 170. THE POSITION OF SHREWSBURY.—The dotted lines represent the position of the old Walls. A. The original Market Place near the Church. B. The Castle guarding the " Neck." C. The Railway Station—built over the river because of lack of room. D. The principal church on the highest point of the town. 1. Market Square, second position of market, near main cross roads. 2. Present Market, third position of market, near main cross roads. 3. Priory. 4. Friary. 5. Low land—originally marshy—now a park. Note the number of bridges and ferries necessary.

people and the plains people meet, *e.g.* Leeds, Oswestry, Verona, Dresden.

(9) If lakes occur in a river's course they often determine town sites.

(*a*) Where the river enters the lake, *e.g.* Duluth on Lake Superior and Chicago on Lake Michigan.

(*b*) Where the river leaves the lake, *e.g.* Athlone (on the Shannon), Geneva, and Detroit.

(*c*) Between two lakes, *e.g.* Keswick, between Lakes Derwentwater and Bassenthwaite, and Interlaken, between Lakes Thun and Brienz.

(10) The centre of a fertile plain. The centre of a river's lowland plain is often a great market centre, *e.g.* Glasgow, York, Paris, Harbin.

(11) Where falls occur. Falls impede navigation, but provide power, firstly for water-wheels and later for the development of hydro-electric power, *e.g.* Killaloe (Shannon), Buffalo, Schaffhausen (Rhine), and all the towns of the "fall line" of the Eastern U.S.A.

(12) Within a river loop (Fig. 170). Sometimes a piece of slightly elevated land is almost surrounded by a river loop or "meander." Such a position is primarily important for defence because the river acts as a moat, *e.g.* Shrewsbury, Durham, Paris.

(13) Where the river swings against a steep rock or hill, *e.g.* Nottingham, Budapest.

Other Factors Affecting Town Sites

As already noted, towns may not be situated on large rivers, and may owe their origin to other factors, the chief of which are enumerated below :—

(1) An abundance of mineral wealth usually attracts settlement, *e.g.* Wigan, Kalgoorli, Magnitogorsk (in the Urals).

(2) Coastal towns may owe their importance to (*a*) a good harbour for a small fishing fleet, *e.g.* Whitby; (*b*) a combination of mountain and marine scenery, *e.g.* the sea-side resorts of North Wales and Cornwall; (*c*) to a stretch of good sands and bathing facilities, *e.g.* the Lido near Venice, Blankenberghe in Belgium, Blackpool, etc.

(3) In marshy areas such as the Fens, towns grew up where there were firm patches of slightly elevated land, *e.g.* Ely, Wells.

(4) Owing to the increase in the size of ships, many large ports now have an outport nearer the sea, viz. Avonmouth for Bristol, Cuxhaven for Hamburg.

(5) Settlements were often determined by the availability of supplies of fresh water. For this reason there is usually a line of villages along the foot of the chalk or limestone escarpments, where springs occur. Such villages are said to be on the " Spring Line " (see Chapter I., page 31).

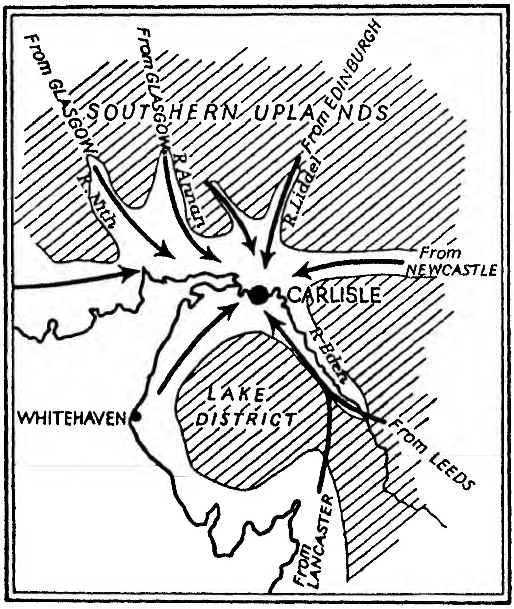


Fig. 171. The Position of Carlisle.—Shows a town located where routes meet.

The sites of many towns and cities may incorporate a number of natural advantages. For instance, Carlisle is at the lowest bridging point of the river Eden; is at a point where firm banks allowed bridge building; is surrounded by streams on three sides, so that the position was suitable for defence; is in the centre of a rich agricultural plain, so that it became a market town; and finally is at the convergence of a number of natural routes from England and Scotland (Fig. 171). Its function as a route centre has made it, in modern times, a very important railway junction.

CHAPTER XXV

FRONTIERS

The Function of a Frontier

In the early days of history, the main function of a frontier was to keep peoples apart, and the value of a frontier was proportional to its efficiency as a means of defence in time of war. As the danger of war decreases, the frontier which provides free intercourse for the interchange of goods and ideas will become the ideal. Frontiers are often classified as (*a*) natural, (*b*) artificial. In the first group are the sea, deserts, mountains, rivers, marshes, and forests, while in the latter are lines of latitude and longitude, other straight lines drawn from one point to another, and also barriers erected for defensive purposes.

The Sea

The sea is the most perfect of all frontiers, for it not only acts as a defensive moat in time of war, but in peace it is an open highway for the nations of the world. To cross it, unless he goes by modern air transport, man must change his mode of travel. It provides little food and no fresh water, and away from coasts there are no reference points to guide the traveller. Thus, until man had reached a high standard of civilisation and learned to navigate by the sun and stars and the compass, no great width of sea could be crossed. Countries whose frontiers are entirely sea frontiers are indeed well blessed. Because of the double function of the sea as a defence and as an open highway, island peoples possess two diametrically opposed characteristics, the narrow-minded insularity which results from lack of travel abroad, coupled with the broad-mindedness of the " Globe-trotting Englishman."

Deserts

Deserts are barriers. They provide neither food nor water except in oases, and the absence of " reference points " in the monotonous waste make it difficult for travellers to find their

way without the use of a compass. The natural defence provided by the desert protected Egypt in the early days of her history, and so allowed the undisturbed development of an early civilisation. In the same way the desert plateaux of Central Asia have protected China and preserved her isolation and independence, allowing the development of a type of civilisation peculiar to China, uninfluenced by the ideas and ideals of other civilised communities. The Arabian Desert imposed a barrier between Egypt and Babylon, so that trading routes between these two centres had to pass northwards through Palestine and Syria to the highways of the "Fertile Crescent." The Sahara Desert is the boundary zone between the Black and White races. No great force of men has ever crossed the Sahara, and though there have been experimental endurance tests by various makes of motor cars, the desert still remains a barrier, one to be avoided even in travelling by air, for a forced landing may well prove disastrous.

Mountains

Mountains are barriers because of their ruggedness, their steep slopes, their coldness, their rarefied atmosphere which often causes mountain sickness, their relative infertility and unproductiveness, and because their inhabitants, though few, may, on account of their virility and their intimate knowledge of the details of the relief, offer stout opposition to strangers. Where a mountain range acts as a barrier between two countries, the actual boundary line usually follows the main watershed as in the Western Alps between France and Italy.

The ease with which a mountain range may be crossed depends on the lowness of the passes. The Alps, with numerous passes, are much easier to cross than the "sierra" type of mountain ranges such as the Pyrenees and the Caucasus, although the latter may be of lower average elevation.

Winter snows add to the difficulty of crossing mountainous areas. Even in England the roads of a low plateau like the Pennines may become impassable during the winter. The Pennines, incidentally, form a barrier between the fundamentally different districts of Lancashire and Yorkshire, both of which have their characteristic peoples and customs.

Where a mountain range is steeper on one side than the other, the country on the gently sloping side has the advantage.

For instance, it is easier for France to invade Italy across the Western Alps than vice versa, a feature which is well illustrated by the fact that the people in the upper valleys of the tributaries of the River Po speak a language closely akin to French. The Andes, between Chile and Argentina are a good example of a mountain boundary.

Rivers

There is a popular belief that a river is a good natural boundary. This is probably partly due to the prominent part played by the river Danube and the river Rhine in European history. Actually, a river seems to have one main advantage, that of being a line easily discernible, but rivers sometimes change their courses, and resultant problems as to the actual line of the original boundary may arise.

Rivers do not separate peoples of different culture, race, or standard of civilisation. A river attracts settlement, because of the natural routes its valleys afford, its water supply, its fertile alluvial soil, and maybe its forest lands which provide fuel and building material. Thus the people of a river basin are often homogeneous in culture, race, and language, and form a distinct national group. From this it seems that a river basin should be the " heart land " of a country, and not its boundary zone. Egypt grew up around the Nile; Babylon around the Tigris and Euphrates; the Indian civilisation in the Indo-Gangetic plains; and the Chinese civilisation in the Hoang-ho valley. So Paris, in the centre of the Seine basin, is the real " heart " of France.

In England rivers are rarely used as county boundaries, except for the Thames, which because of the extensive marshes which used to exist along its banks is a county boundary throughout its length. The River Rio Grande del Norte is the boundary between the U.S.A. and Mexico, but the active frontier is not the river but the desert through which it flows. The River Orange is the boundary between the Cape of Good Hope and S.W. Africa, its effectiveness being due to the fact that the river flows through a deep, steep-sided canyon.

The European conception of the Rhine and Danube as international boundaries probably dates back to the time of the Roman Empire. The Romans extended their influence

north and east of the Rhine-Danube line, but these rivers acted as a sort of defensive moat against the possible incursions of the semi-civilised tribes to the north and east.

In " new " countries rivers were often chosen as boundaries because of the ease of definition. Thus many of the tributaries of the Mississippi are inter-state boundaries. Other examples are the Uruguay, Parana, and Paraguay in South America; the Vaal, Limpopo, and Zambesi in South Africa; and the Murray in Australia. In the " older " countries of the world rivers are rarely used as frontiers.

Forests

Forests are difficult to penetrate, and were thus avoided by early peoples. The migrations of African natives across the grass-lands, and their avoidance of the forest is clear evidence of the barrier nature of forests to primitive peoples. To-day it is difficult to find examples of forests which act as frontiers, but it could be noted that the westward extension of the Andean States of South America was probably limited by the Amazon forest lands. In our own country, the northern limits of Sussex were, in part, determined by the forests of the Weald.

Marsh

Marshland is difficult to cross because it provides no foothold, and on it boats cannot sail. During cold winters, however, a marshland loses its effectiveness as a barrier, and when drained its function as such is completely destroyed. Because of the necessity of reclaiming swamps for agriculture few marshland barriers still exist. The best known is the Pripet Marsh or Rokitno Swamp on the boundary of Poland and Russia. The effectiveness of fenland in protecting Athelney and Ely are well known. In 1914 the burgomaster of Nieuport (Belgium) flooded the valley of the Yser between the Belgium coast and Dixmude, thus stopping the German advance to Calais.

Artificial Barriers

In olden days walls were built against possible enemies. The Great Wall of China, and Hadrian's Wall in the valley of the river Tyne were constructed as lines of defence. The

modern counterpart of the wall is the electrified wire barrier such as was used on the Dutch frontier during the Great War, and which is still used on the mountain frontiers of Switzerland and Italy. Such modern contrivances are not military defences, but serve as a check on people trying to cross the frontier without permits.

An interesting example of a frontier zone is the uninhabited neutral territory between the Spanish mainland and Gibraltar. While such empty zones are effective in keeping people apart, they involve much waste of valuable land.

A striking feature of the political maps of North America, Australia, and parts of Africa is the number of straight line boundaries. Many of these are lines of latitude and longitude, viz. Lat. 49° N. between Canada and U.S.A.; 141° W. between Canada and Alaska; and 22° N. between Egypt and the Anglo-Egyptian Sudan.

It would seem that such lines have been adopted where settlement has proceeded at a greater rate than the accurate survey of the country. Under such circumstances, governments, unable to delimit natural frontiers, and in haste to fix international or interstate boundaries, resorted to lines of latitude and longitude as being the quickest and easiest solution of their problems. Such frontiers completely ignore natural features and, later, may give rise to a crop of knotty problems. This is well seen in South America where, for years, there has been frequent friction between Chile and Peru, and between Paraguay and Bolivia owing to boundary disputes.

The actual survey and the marking of such lines on the ground is very costly, and, in undeveloped areas of little value, is not carried out.

Where, however, valuable products are found, such as the gold of the Yukon-Canada boundary, it becomes imperative that such boundaries should be carefully demarcated.

CHAPTER XXVI

TROPICAL AGRICULTURE

The Difficulties of Tropical Agriculture

Farmers in hot, wet countries have more difficulties to contend with than those of temperate lands. The chief of these difficulties are enumerated below:—

(1) The amazing rate of the growth of vegetation. This is certainly an advantage as far as crops are concerned, but is a great disadvantage in relation to weeds, which grow so rapidly that the farmer has great difficulty in keeping them down under the damp conditions which persist. Native agriculturalists, using primitive ploughs and hoes, are badly equipped to overcome this difficulty.

(2) The number of diseases and insect pests which attack plants is far greater in tropical lands than in temperate lands.

(3) Crops are far more difficult to preserve than in cooler or drier regions, both because they do not keep so well, and because of the actual difficulty of making storehouses proof against the inroads of animals and insects.

(4) Even though climatic conditions favour plant growth, soil conditions are often poor. Much of the soil of tropical areas is a poor reddish soil, known as *laterite*, from which most of the natural plant foods have been dissolved by the heavy rains.

(5) The absence of good roads makes transport and the sale of produce a difficult proposition. There are relatively few roads, and many of these are quagmires of mud and impassable during the rainy season.

(6) Insect pests such as the tse-tse fly are fatal to horses and cattle, and exclude the use of these animals from many parts of Africa. In south-east Asia the water buffalo is important because it can withstand the heat and humidity.

(7) The native peoples of tropical areas are, with certain exceptions such as the Javanese, of a low level of civilisation. Not only have they little inclination to work because of the enervating conditions, but disease tends to lower their efficiency.

Types of Tropical Agriculture

A study of the population map of the world shows that the density of population varies greatly. First of all, there are vast areas which are practically uninhabited. These include desert areas and wide expanses of equatorial forest, scantily inhabited by primitive tribes such as the Amazonian Indians, the Pygmies of Africa, and the backward tribes of the East Indian Islands (excluding Java).

Secondly, there are a few areas with dense population, such as Java.

Thirdly, the remainder consists of vast areas where the population can neither be termed scanty nor dense, but generally under 100 per square mile.

These three classes of density of population correspond roughly to the various types of tropical agriculture. Where the population is scanty forest tribes mainly hunt for their food, and such agriculture as they practise is of the most primitive type, the planting of a few banana cuttings or a little grain. Between the limits of scanty or dense population as in large sections of Africa, between the Sahara and the Kalahari and in similar regions of Asia and South America, native peoples practise agriculture of varying degrees of efficiency. Some merely break up the top soil with a hoe, while others use primitive ploughs and raise considerable crops of millets, corn, cotton, etc.

In forest regions natives plant their crops in temporary clearings. After a year or two when the fertility of the soil is exhausted, the plot is abandoned and a new clearing is made. This system of agriculture is known as the Milpa or Fang type of agriculture (see page 262).

The areas of dense population within the tropics are all associated with either rice culture or plantations.

Location of Plantations

Tropical plantations are generally situated on:—

(1) Islands, *e.g.* Java, Jamaica, Hawaii, Mauritius, Cuba, the Philippines, Ceylon, Formosa.

(2) On coastal plains, *e.g.* the coastlands of the Caribbean Sea, Eastern Brazil, East Africa, Eastern Queensland, and Malay.

With few exceptions, plantations are organised by Europeans. It is for this reason that the distribution of plantations is limited, for the problem of transport is not so acute when plantations are near the sea.

Another characteristic of tropical plantations is that many are situated on hill slopes or plateau land, as, for instance, the coffee plantations of Brazil. One of the greatest factors in plantation development is, however, the labour supply. In this respect primitive peoples are of little use. The main reservoir of suitable labour is south east Asia, which partly accounts for the success of plantation agriculture in the East Indies, in contrast to its absence in Amazonia, remote from supplies of cheap labour.

The Importance of Tropical Products

What tropical products can really be considered important from the point of view of the part they play in world trade? There are certain articles of food such as tea, coffee, cocoa, sugar, and rice, but none of them can compare in bulk or value with the trade in wheat and meat produced in the temperate zone.

Then there are the tropical raw materials, the chief of which is undoubtedly rubber, and there are also various types of hemp. The trade in these raw materials does not approach in value the trade in the wool, flax, and wood-pulp of the temperate zone.

In addition to the food and raw materials, fruits, spices, and oil seeds make up most of the balance of the trade from tropical regions.

A study of the list of British imports shows that the meat and wheat of the temperate zone are the leading imports by value. Sugar and tea are the leading imports from tropical countries, and they rank eighth and ninth respectively on the list of imports. The value of the sugar imports is less than half the value of the meat or the wheat imports. Rubber, another important tropical product, ranks eighteenth on the list, and its value is less than one-sixth that of meat. Thus it will be clear that the value of tropical trade is not as great as is popularly imagined. The misconception seems to be due to the fact that, whereas temperate lands supply the necessities of everyday life—the bread and butter, etc.—tropical lands supply those articles which are often the luxuries of life.

QUESTIONS

1. Of the reasons given to prove the Earth's shape, which show—

(*a*) that it has a curved surface?

(*b*) that it is spherical?

2. Place elastic bands on a large globe to fix the great circles passing through—

(*a*) London and Sydney;

(*b*) Calcutta and New York;

(*c*) Liverpool and Buenos Aires.

Note the places passed through, plot their positions on a mercator's map and join by continuous lines. What do you notice?

3. Prove that a degree of longitude at the equator is twice the length of a degree of longitude at 60° N.

4. Find the distances in miles along the meridians from—

(*a*) London to the latitude of Valencia (Spain);

(*b*) Cairo to Durban;

(*c*) New Orleans and S. Louis.

5. Account for the differences in lighting-up times at the following places :—

May 31st—London, 10.4 p.m.	Manchester, 10.23 p.m.
Exeter, 10.13 p.m.	Glasgow, 10.44 p.m.

How would you expect the times to differ on Nov. 30th and why?

6. The sun is overhead at noon in latitude 10° N. Calculate the height of the midday sun above the horizon at Sydney (N.S.W.), New York and London.

7. A sailor in the northern hemisphere on June 21st observes at midday, looking southwards that the sun is 5° from the zenith. What is his latitude?

8. Is the midday sun always seen in the south in the northern hemisphere? Give reasons.

9. What time will it be in London, Vienna and Calcutta when it is 10 p.m. Tuesday in New York?

10. Describe the ways in which sedimentary rocks may be formed.

11. Draw a map of England and on it mark and name the chief hill systems of the Jurassic Limestone and Chalk escarpments of England.

12. How may the presence of (*a*) chalk, (*b*) limestone in an area be recognised by studying an O.S. map?

13. Name parts of Great Britain in which rocks occur similar to those of the Wicklow mountains, the Antrim Plateau, Central Ireland and the Donegal mountains.

14. What do you understand by the terms—horst, mesa, gneiss, residual mountain, peneplain?

15. Give examples of the various ways in which plains have been formed.

16. Of what economic value to man are the great mountain systems of the world.

17. "Winds are the chief cause of ocean currents." Discuss this by reference to the principal currents of the Indian Ocean.

18. Show how the climates of the coastlands may be affected by ocean currents from a consideration of the coasts and islands of the North Atlantic.

19. Explain why the rivers to the west of the North Sea have estuaries while those to the east form deltas.

20. Distinguish between Spring and Neap Tides.

21. Explain why most places on the coasts of the British Isles have two tides each day. Account for any exceptions.

22. Why does the height of the tide vary (*a*) in different seas; (*b*) at the same place; (*c*) on different days? Give examples.

23. How do the tides affect the ports of the British Isles?

24. Draw a profile of a river in the British Isles selected from your atlas map to illustrate the variations in gradient from source to mouth. Name each section.

25. Describe briefly the effects of ice-sheets passing over a region. How may these glacial effects prove helpful to man?

26. Make a list of the chief lakes of each continent and classify them according to their formation.

27. Examine the coastline of any available Ordnance Survey map and describe its chief features.

28. Obtain pictures of fiord scenery and describe the characteristics of this type of coastline.

29. Classify the islands off the coast of Africa according to their formation. For each island or group of islands name the chief products and towns.

30. Try to find out which are the ten largest cities in the world. Explain conditions which have led to their growth and importance.

31. How are the (*a*) food; (*b*) shelter; and (*c*) clothing of Eskimos, Pigmies, and Kirghiz affected by the environment in which they live respectively?

32. How is it that the Lower Ganges valley is densely peopled and the lower Indus valley is scantily populated?

33. How does the climate of the northern half of Japan differ from that of Great Britain?

34. By making allowance for altitude, and finding the hottest month, annual range of temperature, mean annual temperature, the total rainfall and its seasonal distribution, try to decide in what natural region each of the following places A to M are situated :—

CLIMATE STATISTICS.

The first row of figures gives temperature in F.°, and second row rainfall in inches.

	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.
A	71	74	83	92	95	94	89	86	89	88	80	71
520′	0	0	·1	0	·3	·9	3·5	2·8	1·1	·4	0	0
B	23	24	24	28	33	40	42	41	38	31	29	25
4400′	19	15	17	10	8	8	11	14	17	15	19	21
C	20	23	36	50	62	71	76	74	65	54	37	27
100′	·6	·8	1·4	3·0	4·4	5·2	4·4	3·4	3·0	2·5	1·0	·9
D	62	63	59	55	50	47	46	48	51	54	57	60
160′	1·8	1·5	1·6	1·8	1·9	2·2	2·1	1·8	2·2	2·2	2·5	1·9
E	65	68	72	74	79	81	82	83	81	77	73	69
5′	3·3	2·5	2·8	3·2	5·9	7·9	7·2	7·3	9·9	9·2	2·2	2·2
F	62	62	61	57	53	49	47	48	51	54	57	60
143′	3·6	3·2	3·1	4·1	4·6	5·0	5·9	5·0	4·2	3·9	3·6	3·3
G	75	75	78	82	85	82	80	79	79	81	79	76
37′	0	0	0	·1	·5	21	25	15	11	2	·5	·1
H	78	79	80	81	82	81	81	81	80	80	79	79
104′	8·5	6·1	6·5	6·9	7·2	6·7	6·8	8·5	7·1	9·2	10	10
I	51	52	55	59	64	71	76	77	73	67	59	53
60′	4·1	3·1	3·2	2·6	1·3	0·6	0·3	0·6	1·5	4·0	4 0	4·5
J	55	59	65	70	77	85	91	90	84	72	61	56
141′	0·4	0·5	0·1	0	0	0·1	·5	·2	·2	·2	·2	·3
K	—1	5	15	33	48	60	66	60	48	33	14	1
340′	0·7	0·6	0·7	0·8	1·3	2·7	3·5	3·2	1·5	1·4	1·3	0·9
L	39	39	40	45	50	55	57	56	53	47	44	40
171′	8·7	6·9	7·0	4·0	3·5	3·5	4·6	6·9	8·2	7·9	7·5	11·3
M	74	74	71	67	60	56	55	56	58	61	65	71
197′	0·3	0·3	0·7	1·7	4·9	6·6	6·4	5·6	3·3	2·1	0·8	0·6

35. Why does North Australia have rainfall chiefly in summer, and Southern Australia have rainfall chiefly in winter ?

36. North America produces nearly ten times as much maize as Argentina, yet the latter state is the principal world exporter. Why is this ?

37. Through what climatic regions would one pass in a journey from the north of Scotland to the Cape of Good Hope ? Explain briefly the causes of the climatic changes.

38. How would the size of farms and cultivated products differ in the following regions :—(*a*) Manitoba ; (*b*) Alberta ; (*c*) Japan ?

Why do these differences occur ?

39. Rainfall decreases from Lat. 60° N. to the Tropic on the west of a continent and increases from Lat. 60° N. to the Tropic on the east coast of a continent. Why is this ?

40. Make a list of as many plants as possible from which vegetable oil is obtained. In each case name the chief source of supply. What are the uses of vegetable oils ?

41. Name two areas of the world with—

(*a*) most rain in winter ;
(*b*) most rain in summer ;
(*c*) rain evenly distributed throughout the year.

In each case briefly explain causes of rainfall and its distribution.

42. Where and what are the Llanos, Selvas, Campos, Barren Lands, Pampas, and Steppe ?

43. Compare the climates of Eastern Siberia and the St. Lawrence Valley and account for differences.

44. Give two examples of natural regions in which the corresponding areas on opposite sides of the equator differ climatically. Give details of these differences and add explanatory notes.

45. Which of the steppe land areas of the world has made most progress ? Which of the remaining areas may develop in the near future ? Why ?

46. Consider carefully the geographical position of Russia and suggest reasons for her efforts to develop the Arctic Coast-line.

47. Explain (*a*) why all forested areas in temperate latitudes are not important lumbering areas ; (*b*) why lumbering is less important in equatorial regions than in temperate areas.

48. Give examples to show that similar regions may develop along different lines owing to differences in labour supply.

49. Compare the Savana Lands of Africa, north and south of the Equator.

50. Give examples of important commodities which (*a*) Great Britain, (*b*) U.S.A., cannot obtain in sufficient quantities from their own possessions.

What are the sources of supply and to what extent might they become self-supporting in the future ?

QUESTIONS

51. (*a*) What commodities does Great Britain import mainly the Asiatic Monsoon lands?

(*b*) What alternative sources of supply exist for the commodities selected?

52. Account for the necessity in recent years for restrictions upon the supply of tin, cotton and rubber.

53. What are the chief sources of supply of radium, nickel, asbestos, platinum, vanadium?

54. Give examples of air-routes which would considerably shorten distances between important ports if Polar routes should become practicable.

55. Obtain details of the cost of using the Panama and Suez Canals respectively, and discuss how the charges will affect the use made of these routes.

56. Essay Subjects.

1. White Australia.
2. The Negro in North America.
3. The Russian Five-Year Plan.
4. Transcontinental Railways.
5. Intercontinental Air Routes.
6. Mandated Territories.
7. Manchuria.
8. The Lancashire Cotton Industry.
9. The Development of the Beet-Sugar Industry.
10. The Value of Tropical Colonies to European Powers.

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PRINTED IN GREAT BRITAIN BY UNIVERSITY TUTORIAL PRESS LD, FOXTON, NEAR CAMBRIDGE